Ute Park Fire

Damage Assessment and Burned Area Emergency Rehabilitation Plan

PREPARED FOR

NEW MEXICO DEPARTMENT OF HOMELAND SECURITY AND EMERGENCY MANAGEMENT

PREPARED BY

SWCA ENVIRONMENTAL CONSULTANTS

AUGUST 2018

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New Mexico Department of Homeland Security and Emergency Management

Prepared by

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Cover Photo: Aerial photograph taken during drone reconnaissance showing small patches of moderate and low-severity fire effects on tree canopies, adjacent to high-severity patches. [Photo by Jesse Shuck, SWCA Environmental Consultants]

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DISCLAIMER

This document was prepared under procurement with the New Mexico Department of Homeland Security and Emergency Management. Points of view or opinions expressed in this document are those of the authors and do not necessarily represent the official position or policies of the New Mexico Department of Homeland Security and Emergency Management or the State of New Mexico.

The purpose of this study and report is to identify post-fire threats to human life, critical cultural and natural resources, and infrastructure.

Observations in the report are based upon satellite imagery, on-the-ground evaluations, and computer modeling at the sub-watershed level.

Treatments recommended in this report are aimed at reducing the runoff and erosion damage to life, property, and natural resources. They are based on proven practices developed by SWCA engineers and methods developed by the U.S. Forest Service and can be found in the Burned Area Emergency Response Catalog (BAERCAT). Recommendations were chosen based on soil erosion reduction, long-term effectiveness, cost-benefit ratio, and site-specific implementation probability. There may, however, be alternative site-specific solutions available to protect values at risk which may better fit the landowner's goals and management of their property.

The landowners are not bound to implement any treatments, but must evaluate the risks and their decisions accordingly. This report will be utilized to request funding for emergency stabilization and long-term recovery and restoration.

CHAPTER 1 EXECUTIVE SUMMARY

This report summarizes potential post-fire effects on critical values at risk (e.g., human life and property, public infrastructure, including roads, buildings, water systems, etc.), and degradation of natural resources (soil productivity and hydrologic function); municipal, domestic, and agricultural water supplies; habitat for wildlife; and cultural resources within or in close proximity to burned lands. This damage report was necessary as a majority of the fire occurred on private lands with very little public lands being impacted (New Mexico Game and Fish lands) therefore, no federal nexus was triggered to have a government Burned Area Emergency Response (BAER) team asses the damages and impacts of the fire to critical values and resources at risk.

This rapid evaluation was conducted by a team of resource specialists from SWCA Environmental Consultants (Team), to determine whether the critical values are at risk resulting from imminent post-fire threats or "secondary fire effects," which include increased runoff, erosion, flooding, debris flows, sedimentation, and vulnerability to invasive weeds.[1] This report provides rehabilitation treatment recommendations to conduct emergency stabilization to the vegetation, soils, hydrological, and geomorphic components of the environment, with a primary focus of protecting critical infrastructure and municipal water resources. This report also includes long-term restoration action recommendations to minimize unacceptable adverse environmental impacts resulting from the Ute Park Fire as well as monitoring protocols to determine successes and failures of treatments associated with restoration projects.

The 36,740-acre Ute Park Fire damaged and disrupted watershed function on mostly private lands, and to a limited extent may have even destroyed watershed function on a smaller portion of that area. However, because the Ute Park Fire was a running crown fire and moved rapidly across the landscape (30,000 acres in first 3 days), the Team found that watershed condition had been not impacted as severely as initially anticipated. Although this fire burned with high severity through the overstory vegetation, removing a majority of the forested overstory canopy and protective litter and duff layer, the rapid rate of spread resulted in minimal residence time on the soil surface. Therefore, the soils are relatively intact with fine organics still remaining, both on the surface and in the soil profile, and a viable seed bank of native plants likely still exists. The removal of the protective cover in the overstory canopy above the soil surfaces puts this resource in high danger of being eroded if vegetation ground cover is not reestablished. Overall, the fire burned at a variety of severities with large areas unburned or burned at a low severity, adjacent to areas of significant mortality following stand replacing fire behavior (Figure 1.1).

The first-order fire effects on vegetation and soils are apparent in the immediate aftermath of this fire; however, of equal and sometimes greater impact, are the second-order effects of increased stormwater runoff, which can lead to considerable downstream flooding, impacts to potential infrastructure, and compromised water quality. Runoff is magnified due to the loss of vegetation and the development of hydrophobic soils during intense wildfires. Large portions of the burn scar are now without soil surface vegetation canopy protection, and soils have limited infiltration during rains, which in turn increases runoff, elevates streamflow and sediment production, and can result in little to substantial effects on the physical, chemical, and biological quality of the water. The magnitude of these effects is largely dependent on the size, intensity, and severity of the fire, and on the condition (i.e., healthy or poor) of the watershed at the time of burning.

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[1] Calkin et al. 2007. Assessing Post-Fire Values-at-risk with a New calculation Tool. https://www.fws.gov/fire/downloads/ES_BAR/Assessing_Post-Fire_values-at-Risk_With_New_Calculation_To.pdf

Figure 1.1. Aerial photograph taken during drone reconnaissance showing small patches of moderate and low-severity fire effects on canopy, adjacent to high-severity patches.

Objectives

The overall objectives of this damage assessment rehabilitation plan are to:

- Reduce threats to public safety by implementing "non-structural" treatments to warn the public of danger of flooding and debris flows, including an improved rain gage and stream gage spatial network within the burn scar, rapid warning systems (improved data transmission and emergency communications), warning signs at prominent locations, and temporary road closures.
- Reduce threats to both municipal and agricultural water quality and infrastructure through limiting the sediment delivery into the Cimarron River, Cimarroncito Creek, and other key water ways and reservoirs (i.e., Cimarroncito and Webster Reservoirs and Springer Lake).
- Reduce threats to public safety and property on state highways and county and private roads by stabilizing upland hillslopes and improving drainage conveyances to protect against the erosion and sedimentation that is expected from increased runoff and potential debris flows.
- Reduce threats to public safety and downstream property by stabilizing stream channels and hillslopes across multiple locations.
- Control potential invasion of noxious weeds and non-native plant species within the area, especially along and adjacent to roads and dozer lines used by fire suppression equipment and in existing weed populations within or adjacent to the burn perimeter.
- Reduce threats to property and natural resources (wildlife habitat and water used for domestic and agriculture) from increased runoff, and debris flows, by stabilizing hillslopes and channels in high-severity burn areas.

BURNED AREA DESCRIPTION

The winter of 2017–2018 was one of the driest in recorded history for the area within the Ute Park burn scar, with less than 2 inches of precipitation from October 2017 to May 31, 2018. This resulted in extremely low fuel moisture levels, thus greatly increasing wildfire risk. The following information summarizes key metrics for the Ute Park Fire.

Fire Name – Ute Park

County – Colfax

State – New Mexico

Fire Origin –Thursday May 31, 2018, approximately 02:15 p.m.

Point of Origin – South of Ute Park, New Mexico

Date of Containment – 100% containment at 05:48 p.m. on June 17, 2018

Size – 36,740 acres

Fire Spread – 30,000 acres were burned by Saturday, June 2, demonstrating rapid fire spread in the first two days following ignition.

Location – 1 mile east of Ute Park, New Mexico, along U.S. Highway 64, between Eagle Nest Lake and Cimarron.

Coordinates – 36.553 latitude, −105.103 longitude.

Cause – Unknown.

Jurisdiction – New Mexico, State, and private land.

Watersheds (HUC 12) – Chase Canyon (110800020206) 99 Acres, Cimarroncito Creek (110800020108) 6,336 acres, Cimarroncito Creek-Cimarron River (110800020109) 19,560 acres, Ponil Creek (110800020209) 8,819 acres, South Ponil Creek (110800020204) 713 acres, and Ute-Creek Cimarron (110800020107) 1,164 acres.

Miles of Stream Channels – 28 miles of perennial streams and 86 miles of intermittent streams.

Miles of Roads – 8 miles of U.S. Highway 64 and 52 miles of private and county roads were impacted.

Vegetation Types – Grass, pinyon-juniper, ponderosa pine, mixed conifer, and riparian.

Dominant Soils – Loams, silty-loam, sandy loam.

Geologic Types – Sandstone, shale, mudstone, and claystone.

Incident Commander during Maximum Fire-Fighting – New Mexico State Forestry; Type 3 Incident Management Team.

Personnel– at its peak, over 600 personnel were assigned to the fire.

Structures Impacted – No homes; fourteen outbuildings on the Philmont Scout Ranch on May 31.

Post-fire Suppression Repair Work Was Completed on Containment – Consisted of reseeding within dozer fire lines, reduction of slash, water barring, roads, trails, staging areas, safety zones, and drop points used during fire suppression efforts.

WATERSHED CONDITION

The primary driver of watershed condition post burn relates to the severity at which the soils burned. The soil burn severity map developed by the U.S. Forest Service is depicted in Figure 1.2 below.

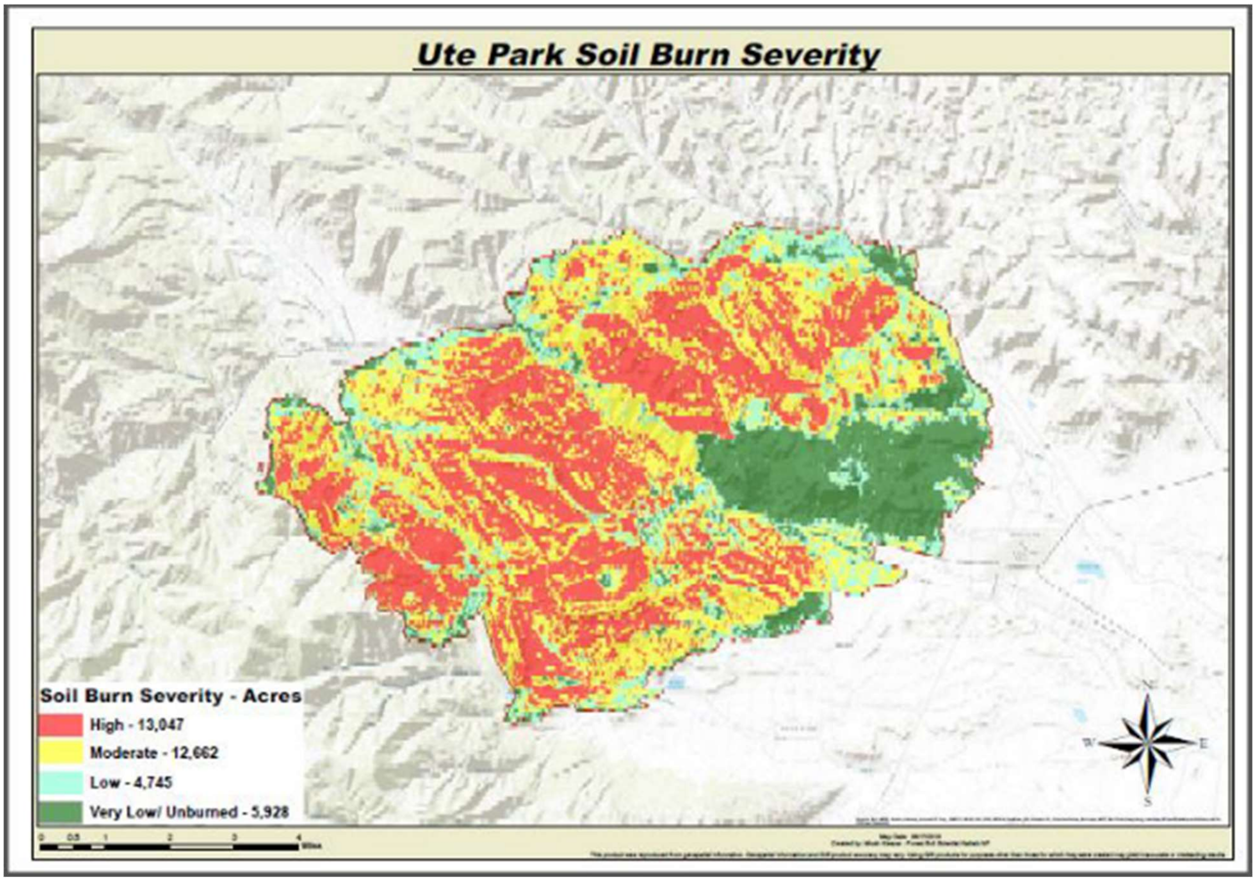

Figure 1.2. Soil burn severity map of the Ute Park Fire.

The classes of burn severity based on the soil burn severity map were:

- 16% unburned (5,928 acres)
- 13% low (4,765 acres)
- 35% moderate (12,662 acres)
- 36% high (13,047 acres)

The data generated from the soil burn severity map as well as from the field reconnaissance and modeling efforts, resulted in the following findings which treatment recommendations were based upon. The results below are a summary of findings of a more comprehensive analysis that can be found in Chapter 3.

Post-fire Erosion Potential for Burned Area – Baseline modeling of post-fire erosion potential shows a range from less than 1 ton/acre on gentle, low-severity burned areas to 10.08 tons/acre in high-severity areas with steeper slopes.

Sediment Potential – The potential for soil to erode is based on slope gradient, hillslope length, sediment texture, burn severity, and vegetation. Based on modeling scenarios: for pre-fire conditions, and a 30%

exceedance design storm, there is a 30% chance that the modeled hillslope will deliver 0.01 ton/acre. In the same scenario at post-fire and high-burn severity, the same hillslope will have a 30% chance of delivering 3.41 tons/acre of sediment during the first year following the fire, which is a 34,000% increase in sediment to the system. However, as vegetation becomes established the model shows sediment delivery recovers to pre-fire conditions after 3 years. In scenarios with high burn severity, slopes equal to or greater than 1000 linear feet in length, with gravelly and sandy loam soils, do not show recovery to pre-fire conditions for 5 years.

Debris Flow – Debris flows are when large amounts of sediment are transported throughout the full length of the hillslope and are generally defined with approximately 50% of the volume is made of sediment/rock/wood particles. Under pre-fire conditions, debris flows naturally occur during heavy precipitation events that cause deep saturation of the soils. However, during post-fire conditions debris flows are more likely to occur because it takes much less rain to trigger these events. Ute Park was determined to be at moderate risk to debris flows following the fire and on July 13, 2018, 0.3 inch of rain resulted in a debris flow that terminated on the alluvial fan upon which Ute Park is constructed (Figure 1.3). Debris flows are expected to continue to be problematic during the first 2 years following a fire. However, as the herbaceous layer recovers, and as organic cover is added to the soil surface, the potential for debris flows decrease over time.

Water Yield – Reconnaissance-level analysis estimates a 600% to 3,300% increase in water yield that may occur during the first few years post-fire. The highest post-fire increases in water yield are predicted to occur in the drainages that feed into the community of Ute Park, and the Ute Gulch area on the Philmont Scout Ranch. Increased water yield has the potential to transport large amounts of sediment and debris that can compromise downstream municipal and agricultural water infrastructure.

Water Quality – The Ute Park Fire is likely to produce significant adverse impacts to water quality relative to municipal and irrigation water supply, fish and other aquatic organisms, and to wastewater treatment systems (septic tanks). Post-fire delivery of ash, sediment, and debris is the greatest concern for surface water health post-fire (Figure 1.4). The large post-fire sediment fluxes may impact drinking water systems in two ways: 1) reservoirs, infiltration basins and water treatment works may be filled with sediment, and 2) high sediment load is likely to increase pre-treatment processing needs and costs for suspended sediment removal. These impacts to water treatment works and reservoirs can affect water use as far as 100 miles away (Meixner 2004). Drinking water treatment processes operate more effectively when source-water quality is constant (U.S. Geological Survey [USGS] 2012). Post-fire hydrology differs from normal hydrologic conditions, especially in the Southwest, because burned watersheds are prone to flash floods following high-intensity/short-duration convectional monsoonal rainstorms that transport substantial amounts of sediment to downstream water bodies in pulses. This has significant implications for water treatment processes.

Figure 1.3. Debris flow generated from the Ute Park Fire that impacted Ute Park on July 13, 2018, following approximately 0.3 inch of rain directly on the burn scar upslope from Ute Park.

Figure 1.4. Sediment-laden stormflow impacting water quality following a convectional storm event.

VALUES AT RISK

Values at risk that are addressed in this report include human life and safety, property, physical improvements, natural resources, and cultural resources, community infrastructure, and economic, environmental and social values (Figure 1.5). The community of Ute Park, the Philmont Scout Ranch, the Vermejo Park Ranch, the Chase Ranch, municipal watersheds, Colin Neblett State Wildlife Management Area, economic benefits from tourism and recreation in the area, and air quality are all examples of values at risk that were adversely impacted by the Ute Park Fire.

Following field reconnaissance, the Team created an extensive list of values from all resource areas that could potentially be threatened by post-fire secondary effects (Figure 1.6). That list included those defined by the Team as critical values, as well as numerous other values:

- Communities at Risk (Ute Park, Cimarron, Springer, Raton and Philmont Scout Camp)
- Infrastructure (community structures, reservoirs, roads, highways, water delivery infrastructure)
- Hydrologic and Watershed Function
- Soil Productivity
- Water Quantity and Quality
- Native Vegetation Community Composition and Productivity
- Wildlife Habitat
- Recreation, Hunting, Tourism, Agriculture, and Ranching

Figure 1.5. Cimarroncito Reservoir is a critical value at risk that has the potential to be impacted by the effects of the Ute Park Fire.

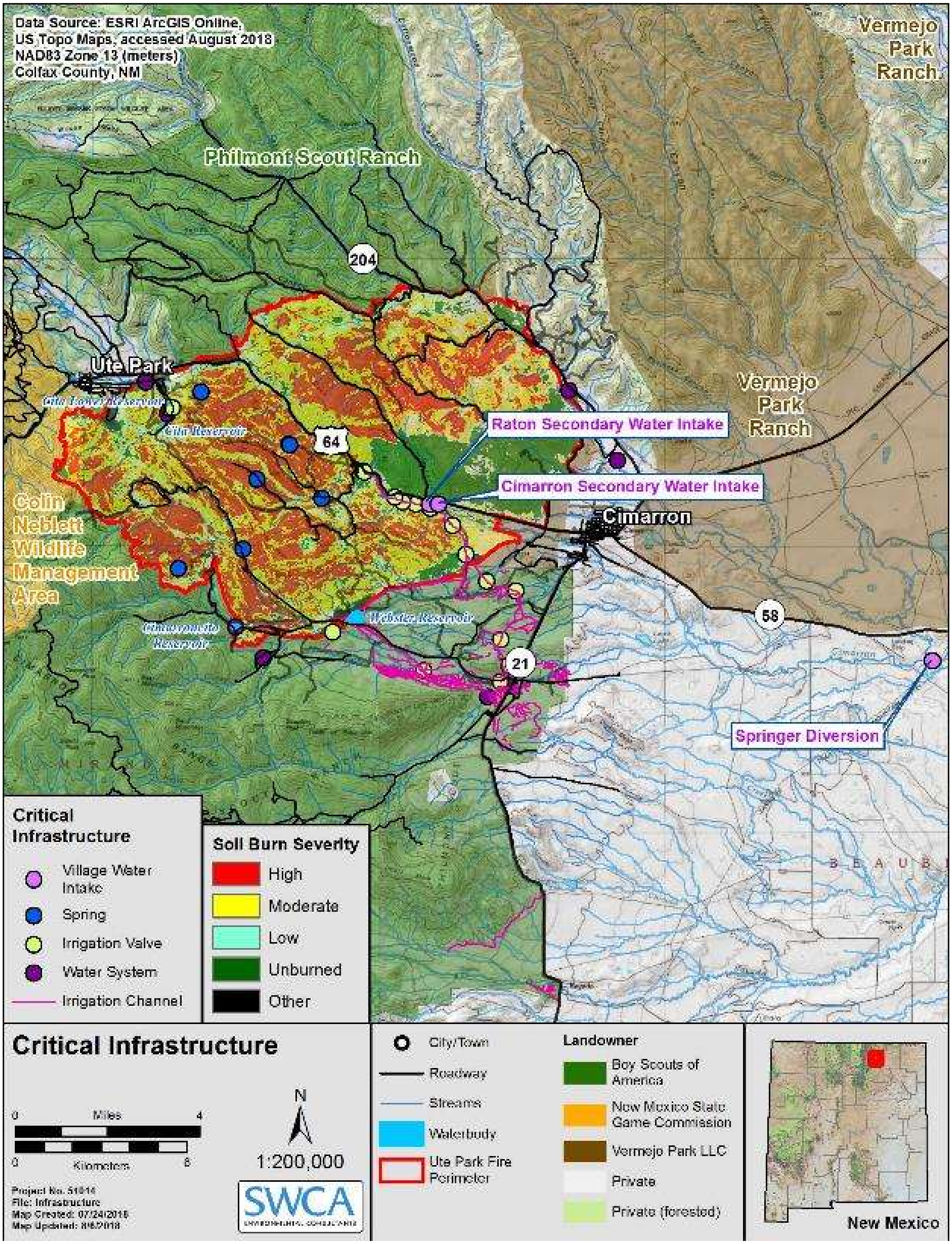

Figure 1.6. Map showing locations of the critical infrastructure that are at a high risk for impacts from the Ute Park wildfire.

Each of the values at risk that were evaluated were assigned a relative level of risk based on the standard risk assessment protocol developed by the U.S. Forest Service for its BAER planning on national forest lands (U.S. Forest Service 2017).[2] The risk assessment protocol involves a case-by-case evaluation of two factors. First, a rating is assigned for the potential likelihood that the particular value at risk would be damaged by elevated flood and sediment erosion from burned areas in the next 1 to 3 years. The ratings are "very likely," "likely," "possible" and "unlikely." Second, a rating is assigned for the relative magnitude of the consequence if the particular value is damaged or destroyed by flood or debris flow. The magnitude ratings are "major," "moderate," and "minor." Application of the two sets of ratings produces an overall risk rating for each value at risk according to the matrix in Table 1.1 below, and the magnitudes of consequences are denoted by colors.

Table 1.1. BAER Risk Assessment (source: U.S. Forest Service 2017)

Probability of Consequence	Magnitude of Consequence		
	Major	Moderate	Minor
Very Likely	very high	Very high	Low
Likely	very high	High	Low
Possible	high	Intermediate	Low
Unlikely	intermediate	Low	Very Low

Table 1.2 below summarizes the threats and risks to values at risk identified by the BAER team for the Ute Park Burn area.

Table 1.2. Summary of Critical Values, Threats, and Risks

Critical Value	Value at Risk	Area with Value	Threat	Risk
Human Life/Safety and Property	Highways	Watersheds draining to U.S. Highway 64	Culverts at risk of blocking, overtopping, and erosion by flood, sedimentation or debris flow.	High to Very High
		Watersheds draining to Highway 21 Bridge	Bridge at risk of blocking, overtopping and erosion by flood or debris flow.	High
		Highway surfaces	Risk of debris flows, flash flooding and sediment deposition of roadways risking safety of motorists and potential closures.	High to Very High
	Secondary Roads	Philmont has secondary roads that are used to access critical infrastructure, e.g., Ute Gulch Road and Cimarroncito Road	Roads at risk of blocking, overtopping and being washed out by flood or debris flows. Risk of temporary closures and impacts to ingress and egress for residents and emergency providers.	High to Very High

[2] Forest Service Manual 2500- Watershed Protection and Management- Interim Directive No. 2520-2017-1. https://www.fs.fed.us/dirindexhome/fsm/2500/wo_id_2520-2017-1.doc

Critical Value	Value at Risk	Area with Value	Threat	Risk
	Bridges on secondary roads	Bridges that allow access to critical infrastructure on secondary roads	Bridges damaged or weakened by fire are at risk of damage or complete displacement by flood or debris flows.	High to Very High
	Homes, Driveways and Outbuildings	Ute Park	Homes, driveways and outbuildings located in floodplains and/or alluvial fans at risk of flooding and debris flows from runoff from burned watersheds.	Very High
	Homes, Driveways and Outbuildings	Village of Cimarron	Homes, driveways and outbuildings located in floodplains and/or alluvial fans at risk of flooding and debris flows from runoff from burned watersheds.	Intermediate to High
	Recreation/Hunting/Tourism	Village of Cimarron, Philmont Scout Ranch, Vermejo Park Ranch, Chase Ranch, New Mexico State Parks, New Mexico Game and Fish, regional tourism	Threats to public safety in back country areas utilized for hiking, hunting, backcountry pursuits from post fire flooding, debris flows; secondary impacts to tourism industry.	High to Very High
	Agriculture/Ranching	Philmont Scout Ranch, private property, irrigated properties downstream	Threats to human life and safety from impacts of flooding on agricultural and ranch areas, and sedimentation impacts to irrigation infrastructure.	High
	Reservoirs and Dams	Cimarroncito and Webster	Loss of storage capacity and poor water quality caused from suspended sediment, sedimentation and flooding.	Cimarroncito – Intermediate Webster – High
	Water Infrastructure	Diversions for Cimarron, Cimarroncito, Philmont, Raton, and Springer	Sedimentation and blockage of intake structures and the increase in turbidity, dissolved oxygen content, nitrates, and ash overwhelm the system and prevent cost-effective water treatment. Damage resulting from flooding and debris flow.	Cimarroncito reservoir intake-High Cimarron River secondary intake (Raton and Cimarron) – High Springer Lake diversion – Intermediate Philmont Municipal water infrastructure – High
	Groundwater wells	Throughout the impacted area	Sedimentation of wells and destruction of well casings from sedimentation, inundation, and contamination of water by flooding.	High
	Irrigation Diversion Canals	Springer Ditch Company	Irrigation diversion turnoffs and canals at risk of erosion and filling by flooding and sedimentation. Long-term operation is threatened.	Intermediate to High

Critical Value	Value at Risk	Area with Value	Threat	Risk
	Septic systems	Residential areas	Buried septic systems located on alluvial fans at risk of failure and or destruction by erosion/sedimentation or debris flows.	Intermediate to High
Natural resources	Non-native invasive plants and noxious weeds	Native vegetation community impacted with high severity	Risk of post-fire weed introduction through seeding or carried in on equipment during recovery efforts.	Low–Intermediate
	Threatened and endangered species	No known occurrence of threatened and endangered species within the burn area	N/A	Very Low
	Wildlife habitat	High-severity stand replacement areas	Loss of habitat, fragmentation	Low
	Native vegetation community	High-severity stand replacement areas	Depleted seed source, change in species composition, denuded soils.	Low–Intermediate
	Hydrologic function	Watersheds burned at high severity and downstream unburned watersheds	Watersheds burned at a high severity are at risk of increased hillslope and channel erosion and increased water yield following storms. Watersheds downstream are at risk of sedimentation, debris flows, and increased channel erosion.	Very High
	Water quality	Cimarron River, Cimarroncito, Turkey Creek	Surface waters are at risk from increased sediments, changes in pH, and nutrient loading, which may impact water quality for both domestic and agricultural beneficial uses.	Very High
	Soil productivity	High-severity stand replacement areas	Degradation of soil productivity through loss of topsoil.	Very High
Cultural resources	Prehistoric sites	Specific locations Unknown	Degradation of unknown sites/ exposure of previously unknown sites increasing risk of looting, vandalism.	Unknown
	Historic sites	Specific locations unknown	Potential scorching and consumption of wooden structures during burn; spalling of rock structures. Threat of flood damage and displacement in debris flows.	Intermediate-High

SUMMARY TREATMENT RECOMMENDATIONS

Treatment recommendations were made based on the resource of concern and included recommendations for vegetation, soils, and hydrological and geomorphological treatments. A more in-depth overview of the treatments and the methods used to identify them is highlighted in the respective sections of Chapter 3. The tables presented below are a summary of the treatment recommendations. Table 1.3 through Table 1.5 provide the project type, a general location for the treatment, a description of the treatment, the approximate timeline and cost and a priority rating (high, medium, or low). The funding code column refers to potential funding sources that are outlined in a matrix in Appendix C, with each row given a letter code. Some activities listed in the table may only be eligible for funding as part of a larger eligible project. Contact information for the appropriate representative for each funding agency is included in Appendix C and those representatives can provide full details regarding project eligibility.

Table 1.3. Vegetation Treatment Recommendations for Post-fire Rehabilitation and Restoration

Vegetation Treatment Recommendations						
Project	**Location**	**Description**	**Timeline**	**Cost**	**Funding Code**	**Priority (H, M, L)**
Herbaceous vegetation rehabilitation for immediate and short-term (< 10 years) erosion and flooding control	High-severity burned steep slopes above Ute Park, U.S. Highway 64, and Turkey Creek	Seed bare soils with sand dropseed grass and annual sunflower within season for development of herbaceous vegetation cover.	August 2018–September 2018	$63,910	A, B, F, G, H, N, Y, AB	H
Vegetation restoration for short-term and long-term (> 10 years) erosion and flooding control, and to initiate native vegetation recovery for wildlife habitat	Same locations as above, plus other large high-severity burn patches where natural vegetation recovery will be slow due to the size of high-severity burn patches and a possible lack of a natural seed bank in the soil.	In addition to the species listed above, seed bare soils with the perennial native grasses: western wheatgrass, blue grama grass, Galleta grass, and the woody shrub four-wing saltbush.	July 2019–August 2019	$83,775	A, B, F, G, H, N, Y, AB	M
Riparian vegetation restoration for short-term and long-term stream stabilization and wildlife habitat	Riparian areas that experienced high-severity fire and loss of most woody trees and shrubs	May not be needed. In 2019 if riparian willows and trees are not recovering, then consider pole and whip plantings	March 2019–June 2019	$30,000	A, B, F, G, H, N, Y, AB	M
Weed control for immediate and short-term non-native weedy plant management	High-severity burn areas adjacent to roads, fire lines and other areas of human disturbance	Monitor areas for the establishment and spread of non-native weedy plant species. Develop weed management plans for particular locations where non-native weedy plants are observed to colonize. Management will be site and species specific. Mandatory power washing of all equipment entering the area.	May 2019–May 2024	$30,000	Y	H
Reforestation of ponderosa pine and Douglas-fir	High-severity burn areas with large patch sizes, where natural regeneration may be limited by a lack of available seed trees.	Seedling planting. Seedlings available from New Mexico State Forestry Conservation Seedling Program. Follow planting guidelines.[3]	Winter	$62/50 trees (bare root) $80/49 trees (one season containerized trees)	A, B, F, G, H, N, Y, AB	M

[3] New Mexico State Forestry- Conservation Seedling Program- http://www.emnrd.state.nm.us/SFD/treepublic/Planting.html

Table 1.4. Soil Treatment Recommendations for Post-fire Rehabilitation

Soil Treatment Recommendations						
Project	**Location**	**Description**	**Timeline**	**Cost**	**Funding Code**	**Priority (H, M, L)**
Placement of wattles along contours	Focus on hillslopes burned at high severity above critical infrastructure (springs, wells, turnouts) and resources. See Figure 3.42 below for priority treatment locations	Wattles are expected to be used in high-burn severity areas where soil erosion and water quality deterioration are at risk and where Log Erosion Barriers (LEB) are not practical.	Initially after fire and 1 year following	$1,500–$5,500/acre	A, B, D, F, G, H, I, J, M	H
Spreading of slash/mulching (Mastication)	High severity areas on hillslopes 20% or less and adjacent to active stream channels or critical infrastructure. See Figure 3.42 below for priority treatment locations.	Mastication is a mechanical way to thin forest stands following wildfire. Masticators have the ability to mulch biomass to create a ground cover that helps stabilize the soils.	Initially after fire and 1 year following	$450–$850/acre	A, B, D, F, G, H, I, J, M	H
Log Erosion Barriers	Treatments should be focused on slopes less than 40% burning at a high and moderate severity. The slopes draining into the Cimarron and the Cimarroncito River should be areas of focus.	Designed to slow runoff, and capture and store sediment through decrease the length of the slope. Arranged in a bricklayer pattern on hillslopes.	Initially after fire and 1 year following	$550–$1,700/acre	A, B, D, F G, H, I, J, M	H
Seeding with native species	Seeding should be done in concert with wattles, log erosion barriers and mulching or in areas where access is limited. Areas above Ute Park would be good to seed since it is rugged terrain with steep slopes.	Seed bare soils with western wheatgrass, sand dropseed grass and annual sunflower for immediate development of herbaceous vegetation cover.	During treatments and in future years if it is noticed no natural recruitment is occurring	$50–$200/acre	A, B, D, F, G, H, N, Y, AB	L
Private domestic drinking water wells	Primary Ute Park and Philmont Scout Camp	Homeowners using private well systems are encouraged to complete a visual inspection of their system and repair any visible damage. immediately. If the well system was damaged by the fire a licensed well technician should inspect the system. Encourage proactive measures to reduce damage, such as sandbagging, flow routing, and well grouting and protection of the well casing.	Inspection after large storm events	N/A	AF	H

Soil Treatment Recommendations						
Project	**Location**	**Description**	**Timeline**	**Cost**	**Funding Code**	**Priority (H, M, L)**
Irrigation waters	Throughout burn scar	Use of settling ponds upstream of turnouts and bypassing sediment-laden waters should help in reducing excessive sediment and ash in irrigation water.	Inspection after large storm events		A, B, F, G, H, I, J, M, P, W, X, AE	M
Septic systems	Ute Park, Cimarron	Post-fire flooding may result in erosion of surface cover and damage to below ground components. Homeowners should inspect systems after flood events for damage to PVC piping aboveground. If visible damage has occurred or if the system is malfunctioning (backing up), discontinue use and contact local health department fir guidance and instruction on repair and restoration of the system.	Inspection after large storm events		G, K, U, W, X, AE	H

Table 1.5. Hydrological/Geomorphological Treatment Recommendations for Post-fire Rehabilitation

Hydrologic/Geomorphological Treatment Recommendations						
Project	**Location**	**Description**	**Timeline**	**Cost**	**Funding Code**	**Priority (H, M, L)**
Emergency Alert System	Various	Need additional reliable data to account for the variability in location/intensity of thunderstorms. Need to put in a warning system for flash flood and better calibrate/understand post-fire water yield impacts. A rain and stream gage network and early warning communication system (reverse 911 or siren) would provide protection to community members downstream of the burn scar.	Immediate	$75,00–150,00/year	A, F	H
Bathymetric survey of reservoirs	Cimarroncito, Webster, Springer Lake	Bathymetric surveys of these bodies of water would provide a profile of the bed which could be used for pre and post dredging in the case of these reservoirs fill with sediment and becoming inoperable.	Initially after fire before sedimentation occurs		H, I, S, T	H
Concrete Wall Barrier (CWB) sediment removal	Along U.S. Highway 64	NMDOT installed CWBs along U.S. Highway 64 to prevent sediment and debris from entering the roadway. These barriers are temporarily working, however, as sediment accumulates following runoff events the functionality decrease and the risk for catastrophic failure increases. It is recommended to replace these CWBs with other movable/temporary flood control structures that have a secure base and continuous wall to route water and sediment. If CWBs fail, significant damages due to flooding and sedimentation would be expected downstream.	Inspection should be made following storm events to check the levels of accumulated sediment and debris	NA	NA	H
U.S. Highway 64 closure	Eagle Nest to Cimarron	Continue to implement road closures during adverse weather conditions.	Road closure will likely continue for up to 3 years as the burn scar recovers	NA	D	H
U.S. Highway 64 warning signage	Eagle Nest to Cimarron	Install signage in Eagle Nest and Cimarron notifying motorists of potential water and sediment on roads that could create hazardous conditions.	For at least 3 years post-fire	NA	D	H
Silt fencing/wattles	Around domestic wells and springs	Silt fencing and/or wattles can be used to keep post-fire ash and sediment from covering the well casing or filling in springs.	Initially after fire before sedimentation occurs	$150–$500 structure	A, B, D, F, G, H, I, J, M, N	M

Hydrologic/Geomorphological Treatment Recommendations

Project	Location	Description	Timeline	Cost	Funding Code	Priority (H, M, L)
Stabilization of stream channels at top of watersheds	First order streams in Ute Gulch,	Rock dams and log structures could be placed in channels that are actively down cutting. These structures are designed to increase channel friction and decrease channel erosion rates. Appendix F has BAER protocols for these treatments.	Initially and up to 10 years post fire as issues become evident	Varies $5,000–$500,000	A, B, F, G, H, I, J, M	M
Culvert replacements	Multiple Complete inventory to be conducted.	Replace culverts to appropriate size to convey the increase in sediment and water. Install new culverts at headcuts and low water crossings to route flow, reduce mass erosion and potential capture of roads. Replace under-sized culverts and route flow along U.S. Highway 64. Sediment Reduction ~ $300/Ton (2,500 TONS)	Initially and 1 year following fire	~$15,000 ea.	A, B, F, I, J, K, L, M, T, U, W, AE	Varies based on location
Bridge replacements	Two bridges prioritized in SWCA study. USACE currently conducting more detailed-level assessment.	Replace burned bridges and bridges undersized to convey the increase in water and sediment. Replace burned bridges at: Cimarroncito Reservoir Access, and Martinez Springs Access. Sediment Reduction ~ $500/Ton (4,000 TONS)	Immediate at critical infrastructures sites (e.g., Cimarroncito Reservoir), others following first 2 years.	~$75,000–$200,000	A, B, E (only if damaged during fire suppression activities) F, I	Varies based on location
Channel and floodplain restoration in depositional reaches	Multiple locations to be determined during Predictive Level Assessment (PLA)	Mitigate for the increase in sediment and water by resizing channels to be stable under post fire water and sediment conditions. Up to 12,500 lf of Restoration Cimarron River and other drainages @ ~$400 lf of Restoration Sediment Reduction ~ $120/Ton (41,500 TONS)	Following first 2 years	$75,000–$5,000,000	A, B, F, G, I, J, V	H
Bank stabilization in transport reaches	Multiple locations to be determined during the PLA	Mitigate for the increase in sediment and water and stabilize reaches to reduce in-channel erosion potential. up to 5,000 lf of Restoration Cimarron River and other drainages @ ~$150 lf of Restoration Sediment Reduction ~ $150/Ton (5,000 TONS)	Following first 2 years	$75,000–$750,000	A, B, F, G, I, J, V	H

Hydrologic/Geomorphological Treatment Recommendations						
Project	**Location**	**Description**	**Timeline**	**Cost**	**Funding Code**	**Priority (H, M, L)**
Headcut, low-water stream road crossings, and gully stabilization	Multiple locations to be determined during the PLA	Install on-site boulders and logs as grade control at steep high burn gullies and road crossings. ~ 10,000 lf of Small supply tributaries @ ~$200 lf of Restoration Sediment Reduction ~ $100/Ton (20,000 TONS)	Immediate	$25,000–$2,000,000	A, B, F, G, I, J, V	M
Sediment Basins (including new construction and utilization of existing ponds pending landowner approval)	Multiple locations to be determined during the PLA	Approximately 6 Sediment Basins: -Hummingbird subwatershed -Antelope Mesa (2) -Ute Gulch -Deer Lake Mesa Alluvial Fan -UT-to Ute Park subwatershed @~$250,000–2,000,000 each Sediment Reduction~$75/ton (110,000 TONS) Periodic maintenance and dredging may be required, especially following storm events.	Immediate within the drainage at Ute Park and Cimarron Canyon. Others following 2–5 years.	$1,500,000–$8,000,000	A, B, F, G, I, J, V	H
Cimarroncito intake structure	Downstream Cimarroncito Reservoir	The intake structure reservoir pool is immediately downslope of a high burn severity steep hillslope. Ash and debris were filling the pool during the time of survey. Replace structure with a larger, higher crest elevation, designed with an intake pump raised off the bottom of the pool, with a strainer/filter system.	Immediate	~$250,000	A, B, F, I, J, K, L, M, T, U, V, W, AE	H
City of Cimarron secondary water intake structure	Located on the Cimarron River	The intake structure is completely clogged with sediment and inoperable. The low-head channel wide diversion structure is not deigned with appropriate geometry and position, which exacerbates the sedimentation issues. Project should be combined with channel restoration and debris flow/floodplain stabilization.	Immediate	~$500,000	A, B, F, I, J, K, L, M, T, U, V, W, AE	H

AGENCY AND STAKEHOLDER COORDINATION

The assessment process was conducted with close coordination with other agencies and stakeholders to gather information on work they are completing, to gather relevant infrastructure data, to share ideas, and to coordinate efforts to ensure that efforts were not being duplicated. This coordination effort also included holding a stakeholder meeting after the initial damage assessment was complete to highlight the findings and recommendations, and to discuss the time frame of the work being completed by the other agencies. This meeting was also an opportunity for the key stakeholders to highlight areas of critical concern and at risk of impacts from the Ute Park Fire.

The level of involvement varied across agencies and key stakeholders, and all of the partners involved in the post-fire restoration work are included in Table C.1 in Appendix C. This table also highlights the deliverables expected, key contacts, and potential sources of support and funding. Not all of the parties involved conducted damage assessments, or completed reports. The U.S. Army Corps of Engineers (USACE) and the Natural Resources Conservation Service (NRCS) are two federal agencies that are compiling comprehensive damage assessments and associated reports. This information will complement and will add to the modeling and treatment recommendations presented in this report. The reports being written by the USACE and NRCS are expected to be completed in mid-August. The hydrology and hydraulics report being prepared by the USACE will provide addition information to complement this report, and may be used to target additional areas for treatments that this report and the NRCS report may not include.

Additionally, the USGS is providing both stream gaging and precipitation data in areas within the burn scar. In response to the fire, the USGS installed additional rain gages in order to aid in the ability to forecast stormflows. The USGS and other partners including the National Weather Service are currently evaluating the burn scar area to determine strategic locations where additional rain gages and stream gages could be potentially installed to develop a comprehensive early warning system for the communities downstream of the burn scar. Implementation of such an early warning system of additional gauges will depend upon availability of additional funding. This coordination with the USGS and local stakeholders is expected to continue into the future.

CHAPTER 2 PRE-FIRE CONDITIONS

FIRE BACKGROUND

The Ute Park Fire ignited on Thursday, May 31, 2018, and burned 36,740 acres of the Sangre de Cristo Mountains, west of Cimarron, in Colfax County, New Mexico (Figure 2.1). The ignition was located south of the community of Ute Park, New Mexico, and spread east along both sides of U.S. Highway 64, which is one of the only routes that cross the Sangre de Cristo Mountains from east to west. Much of the fire occurred on the nationally renowned Philmont Boy Scout Ranch as well as other private parcels, including Chase Ranch, Vermejo Park Ranch, and the State-managed Colin Neblett Wildlife Management Area.

COMMUNITY DESCRIPTIONS

The Ute Park Fire impacted a number of communities and entities within Colfax County (see Figure 2.1).

Ute Park

The unincorporated community of Ute Park is located at an elevation of 7,431 feet along U.S. Highway 64 in Cimarron Canyon at the confluence of Ute Creek with the Cimarron River. The full-time population of the village, according to the 2010 census, was 71 people (U.S. Census 2010). There are also many second homes (summer homes) located within the community. The overall membership of the Ute Park Home Owners Association is over 200 members (ARC 2015). Many of the homes are located in the grassland meadow along the highway, but houses are also located in the forest, particularly along the southern boundary of the meadow. Wildfire risk and hazard for Ute Park are described in detail in a Community Wildfire Protection Plan (CWPP) that was prepared for the community in 2006, and is available on the New Mexico Energy Minerals and Natural Resources Department (EMNRD), Forestry Division's website (EMNRD 2006). Ute Park was included in the 2008 Colfax County CWPP and the Cimarron Watershed Alliance CWPP (2008) which provides additional information concerning the wildfire threat and actions necessary to mitigate the threat to Ute Park. Because the community is listed as high risk within a valid CWPP, funding for future wildfire mitigation measures would be more readily available. The fire started just upslope from the community.

Cimarron

The Village of Cimarron is located at an elevation of 6,430 feet in a small valley where the Cimarron River leaves the mountains and enters the plains. This creates a variety of vegetative types with pinyon-juniper on the ridge to the north, scattered pinyon and juniper on rolling hills in the south, grasslands to the east, and grasslands with scattered pinyon and juniper to the west. Cutting through the Village is the Cimarron River with a mixture of cottonwoods, willows, grass, and some invading junipers (SEC 2008). Like Ute Park, Cimarron is included in the 2008 Colfax County CWPP and the Cimarron Watershed Alliance CWPP. The Village was impacted heavily by the fire, due to air quality impacts, road closures, and evacuations.

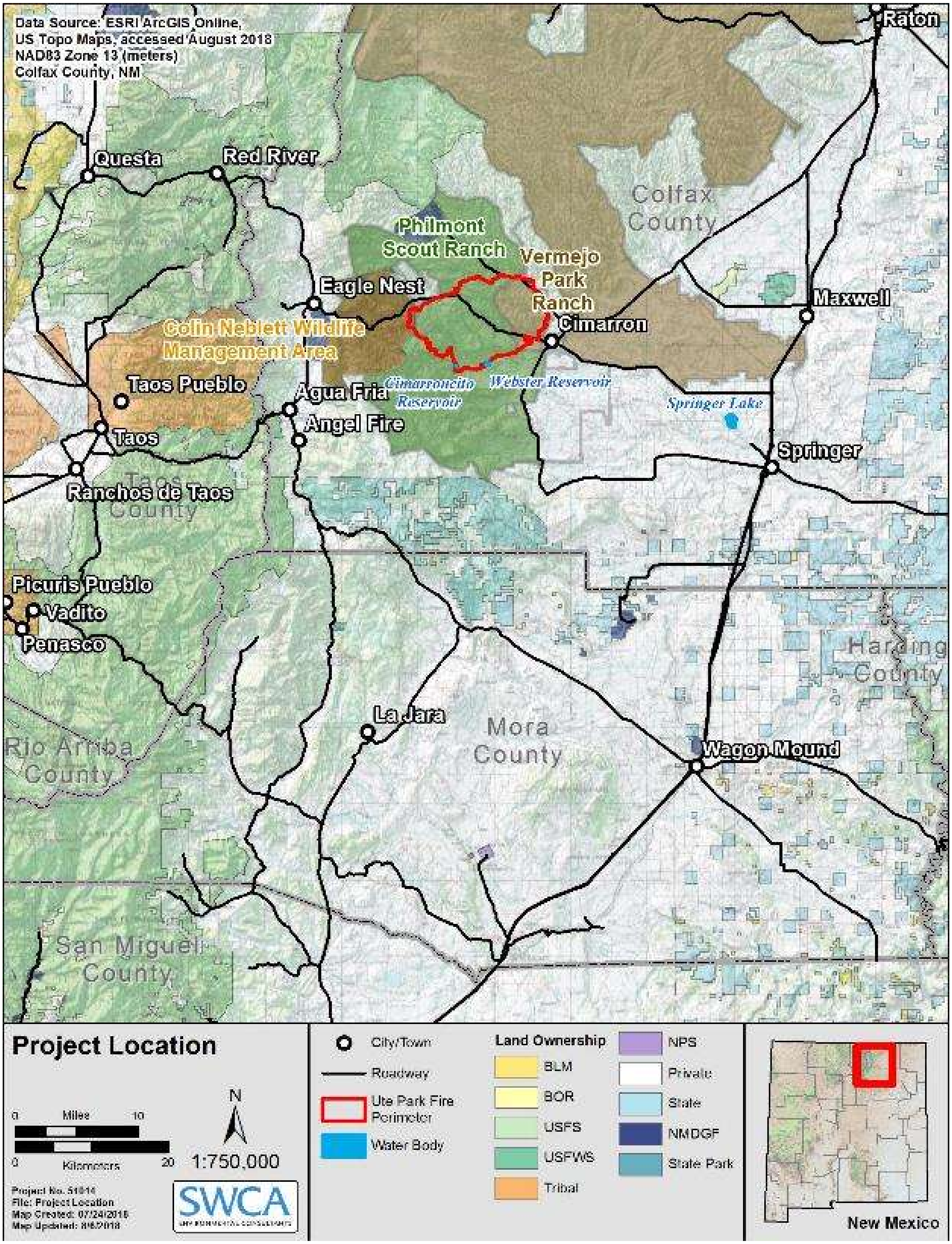

Figure 2.1. General location map of the Ute Park Fire.

Philmont Scout Ranch

Much of the land within the burn perimeter is owned by the Boy Scouts of America, Philmont Scout Ranch (Figure 2.2); approximately 26,442 acres of the ranch burned in the Ute Park Fire. The Philmont Scout Ranch (Philmont) comprises more than 214 square miles of rugged mountain and backcountry terrain. Elevations range from 6,500 feet in the southeast corner, to 12,441 feet at the peak of Baldy Mountain, located on the ranch's northwest boundary. There are nine watersheds in Philmont: the Rayado River, Urraca Creek, Cimarroncito Creek, Sawmill Creek, the Cimarron River, Turkey Creek, Dean Canyon, the Ponil River, and Ute Creek. Philmont Scout Ranch supports a wide variety of flora, from grasslands to savanna woodlands and dense forests. Trees range from plains cottonwood, to pinyon-juniper, ponderosa pine, mixed conifer, spruce-fir, and quaking aspen.

Philmont allows selective timbering to promote healthy forests. In addition to native flora, Philmont grows alfalfa hay for livestock; has herds of cattle that rotate through several backcountry pastures; and has 4,400 acres (18 km^2) of buffalo pasture which supports approximately 100 adult buffalo as well as their calves.

Figure 2.2. View of Philmont Scout Ranch.

Additional Private Property

There are 28 private property parcels within the Ute Park Burn area, with a total of 36,740 acres burned. Most parcels are around 1 acre in size. The largest private parcel, with the exception of the Philmont Scout Ranch, is Vermejo Park Ranch (Vermejo), which is located in the eastern portion of the burn area: 9,502 acres of Vermejo burned in the Ute Park Fire. Vermejo Park Ranch comprises 590,823 acres, and lies mainly in western Colfax County, with elevations ranging from 5,850 feet on the Canadian River near Maxwell, to 12,931 feet on the western boundary of the ranch. Most of the ranch consists of Park Plateau, part of the Raton Basin, a dissected tableland. The Chase Ranch, located adjacent to Philmont Scout

Ranch and managed by Philmont as a working cattle ranch, was also impacted in the fire, with 316 acres burned.

Most private properties in the burn area contain the typical vegetation communities of the southern Rocky Mountains, including Great Plains grassland and steppe vegetation below 6,500 feet; pinyon-juniper woodland from 6,400 to 7,800 feet, especially on southern aspects; ponderosa pine between 7,100 to 8,400 feet, and mixed conifer consisting of Douglas-fir, white fir, and ponderosa pine between 7,000 and 9,800 feet.

Colin Neblett Wildlife Management Area

Colin Neblett Wildlife Management Area (WMA) is managed by the New Mexico Department of Game and Fish and is located between the village of Eagles Nest and community of Ute Park, straddling both sides of U.S. Highway 64. Approximately 418 acres of the Colin Neblett WMA burned during the Ute Park Fire. The Colin Neblett WMA comprises 33,116 acres in total, and provides hunting and fishing access and habitat for deer, elk, beer, turkey, and other wildlife species.

FIRE HISTORY

There have been two large fires close to and within the burn area in the last 20 years. The Casa Fire burned 27,452 acres in 2006, and the Ponil Complex Fire burned 97,470 acres in 2002, including 30,000 acres of the Philmont Scout Ranch (Figure 2.3) and came close to the summer home area and Ute Creek and Express Ranches. Like the Ute Park Fire, the Ponil Fire burned with a mosaic of burn severities (Hayes and Robeson 2011), with high-severity areas being a focus of post-fire activity for watershed protection, including contour felling and tree planting. A number of post-fire effects have resulted from the fire, including post-fire flooding, even 13 years since the fire. High levels of sedimentation, debris plugs, significant channel erosion and downcutting, and impaired aquatic habitat have been reported within the Ponil watershed. According to surveys completed by the Cimarron Watershed Alliance (CWA), natural regeneration of understory vegetation, particularly along Ponil Creek, is occurring; however, overstory riparian vegetation is still lacking, which is contributing to high water temperatures and impaired aquatic habitat within the creek (CWA 2013).

Since the Casa Fire and Ponil Complex Fire, residents of Ute Park and surrounding communities have become increasingly aware of the need to mitigate against wildfire threat and post-fire effects on their communities. Although there has been recent progress with adoption of Firewise practices in communities in the region, the level of defensible space around properties varies widely and additional fire mitigation work is needed. The CWA has actively pursued defensible space projects in the region and has led most post-fire restoration activities associated with past fire occurrence.

LAND USE

The topography of the area is mainly steep, heavily forested land, broken up by the Ute Park meadow area and by the narrow Cimarron Canyon. Land ownership within the burned area is predominantly private, with land use primarily ranching, agriculture, and recreation (Table 2.1). Agricultural uses are mostly livestock grazing with some occasional timber utilization. Recreational uses include fishing, hunting, backpacking, and camping.

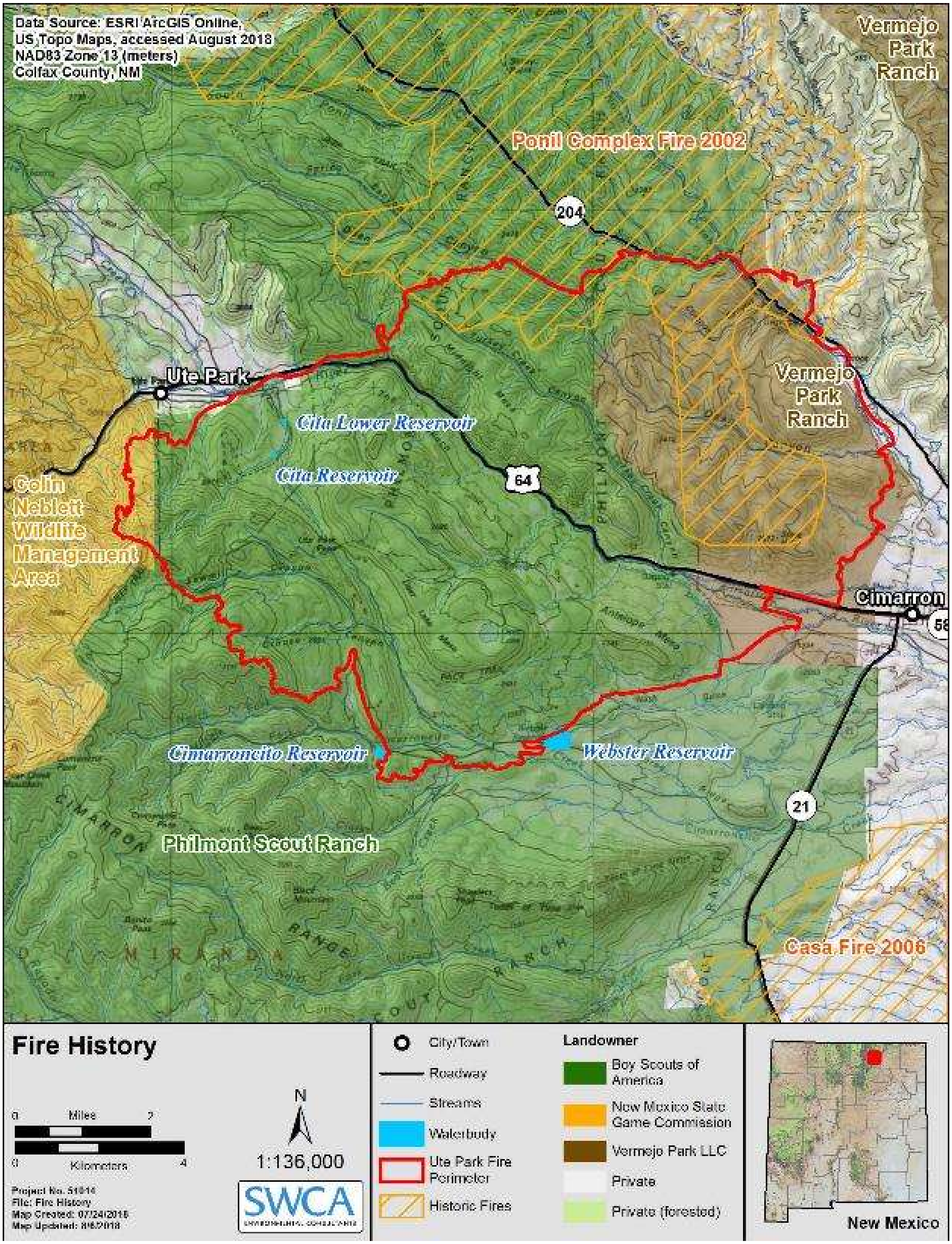

Figure 2.3. Recent wildfires relative to the Ute Park Fire perimeter.

Table 2.1. Burned Areas within the Burn Perimeter by Land Ownership

Land Ownership	Acres within Burn
Philmont Scout Ranch (including Cimarroncita Ranch)	26,442.19
Vermejo Park Ranch	9,502.92
Colin Neblett Wildlife Management Area	418.13
Chase Ranch (managed by Philmont Scout Ranch)	316.35
Other private	61.00

GEOLOGY AND SOILS

Geology within the burn area is diverse. The area encompasses part of the Southern Rocky Mountains Province and is characterized by high mountain areas with elevations ranging from 7,000 to more than 12,000 feet. Along the Cimarron River, Ponil Creek, and lower Rayado Creek, the predominant geologic formations are sandstone, shale, mudstone, and claystone. Additionally, a large area in the southeastern part of the Cimarron watershed consists of Pierre Shale and the Niobrara formation (University of New Mexico [UNM] 2010). Finally, the western part of the watershed consists of limestone, alluvial and colluvium deposits, and metamorphic rocks (UNM 2010).

There are 18 soil map units in total in the Ute Park burned area, but two units comprise nearly 60% of the total area (Figure 2.4). These soils are the Fuera-Dargol-Vamer association which comprises almost 30% (10,868 acres) of the burn scar, and the Midnight-Rombo-Rock outcrop complex which comprises roughly 29% (10,510 acres) of the burned area (Table 2.2). These soils are both characterized as well drained, however, depth to restricted layers range from 16 to 70 inches due to rock outcroppings and slopes average 50 percent. These soils are from alluvium materials derived from sandstone and shale and/or colluvium derived from sandstone and shale. In general, the area is dominated by mostly clays, loams, silt loams, and sandy loams.

The major hydrologic soil groups within the fire are hydrologic groups C and D, which are characterized as shallow soils with moderate to rapid runoff rates. Hydrologic soil groups are groupings based on the premise that soils found within a climatic region that are similar in depth to a restrictive layer or water table, transmission rate of water, texture, structure, and degree of swelling when saturated, will have similar runoff responses. The classes are based on the following factors: 1) intake and transmission of water under conditions of maximum yearly wetness, i.e., thoroughly wet, 2) soil not frozen, 3) bare soil surface, and 4) maximum swelling of expansive clays (if applicable). The slope of the soil surface is not considered when assigning hydrologic soil groups. There are four hydrologic soil groups:

- Group A: Soils with low runoff potential when thoroughly wet
- Group B: Soils with moderately low runoff potential when thoroughly wet
- Group C: Soils with moderately high runoff potential when thoroughly wet
- Group D: Soils with high runoff potential when thoroughly wet

Hydrologic groups C and D soils are the most common group within the burn scar and present higher risks for runoff and erosion in a post-fire environment (see Table 2.2).

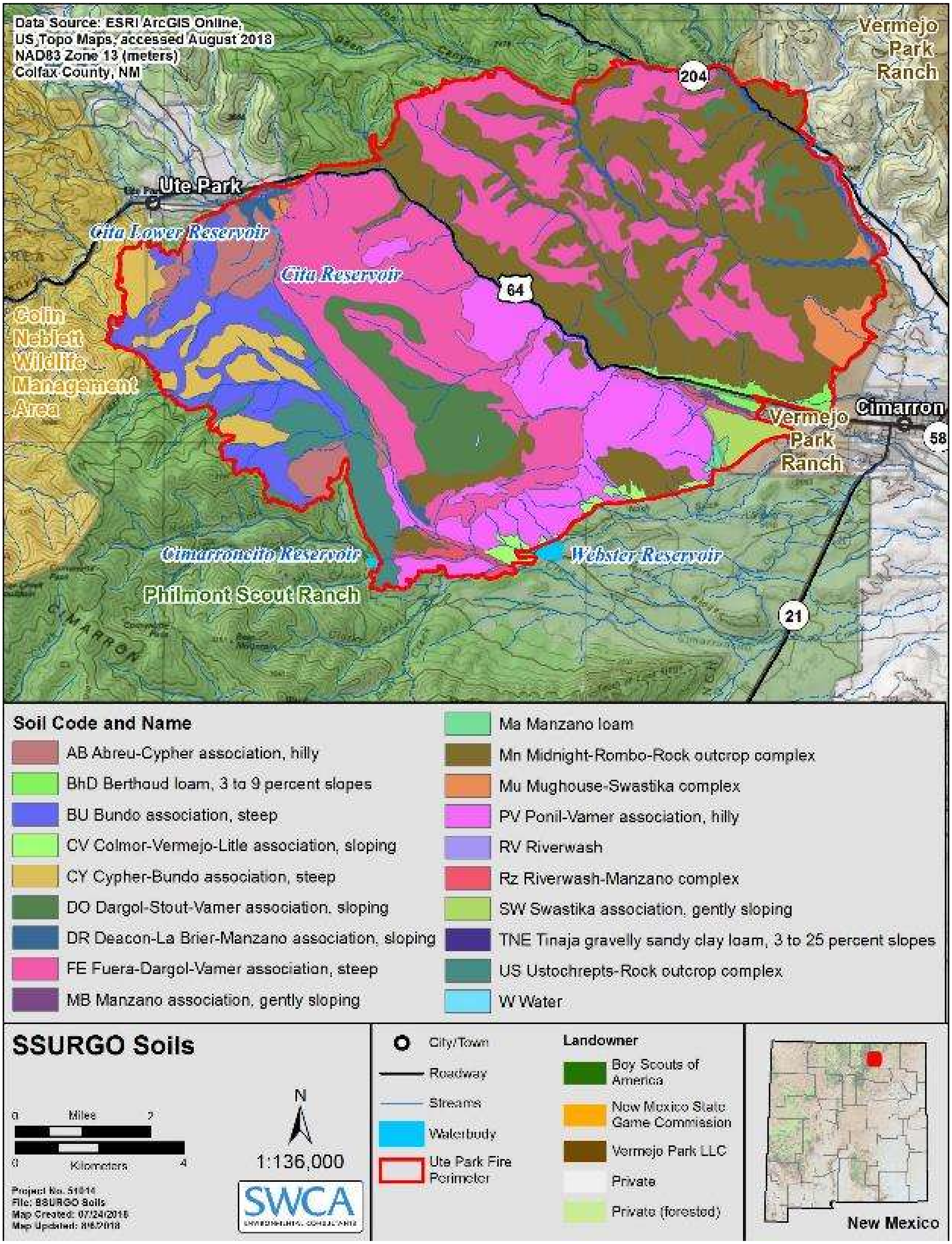

Figure 2.4. Soil map for the Ute Park Fire area.

Table 2.2. Soil Units Mapped within the Ute Park Fire Boundary

Map Unit Code	Map Unit Name	Hydrologic Groups	Acres in Area of Interest	Percent of Area of Interest
AB	Abreu-Cypher association, hilly	C	1,302.1	3.5%
BhD	Berthoud loam, 3 to 9 percent slopes	B	358.1	1.0%
BU	Bundo association, steep	A	2,351.9	6.4%
CV	Colmor-Vermejo-Litle association, sloping	D	268.7	0.7%
CY	Cypher-Bundo association, steep	D	1,423.9	3.9%
DO	Dargol-Stout-Vamer association, sloping	D	2,012.3	5.5%
DR	Deacon-La Brier-Manzano association, sloping	D	575.5	1.6%
FE	Fuera-Dargol-Vamer association, steep	D	10,868.4	29.6%
Ma	Manzano loam	C	63.7	0.2%
MB	Manzano association, gently sloping	C	32	0.1%
Mn	Midnight-Rombo-Rock outcrop complex	D	10,510.2	28.6%
Mu	Mughouse-Swastika complex	C	534.5	1.5%
PV	Ponil-Vamer association, hilly	D	4,211.6	11.5%
RV	Riverwash	not applicable	2.3	0.0%
Rz	Riverwash-Manzano complex	not applicable	463.4	1.3%
SW	Swastika association, gently sloping	C	346.9	0.9%
TNE	Tinaja gravelly sandy clay loam, 3 to 25 percent slopes	B	0.5	0.0%
US	Ustochrepts-Rock outcrop complex	C	1,440.3	3.9%
W	Water	not applicable	3.5	0.0%
Total			**36,769.8**	**100.00%**

HYDROLOGY

There are six 12-digit hydrologic unit code (HUC 12) watersheds that were impacted by the fire (Figure 2.5). Table 2.3 below list the acreage of the watershed within the burn and the severity at which each watershed was burned.

Table 2.3. Number of Acres of Each Burn Severity Class by HUC 12 Watershed

Watershed (HUC 12)	Total Acreage in Burn	Unburned (acres)	Very Low Severity (acres)	Low Severity (acres)	Moderate Severity (acres)	High Severity (acres)
Chase Canyon	98.5	9.5	46.0	33.8	9.1	0
Cimarroncito Creek	6,335.5	112.7	220.2	697.6	2,311.6	2,993.4
Cimarroncito Creek-Cimarron River	19,559.5	222.1	3,127.3	2,167.9	6,826.4	7,215.8
Ponil Creek	8,819.0	63.4	2,105.4	1,306.8	2,917.8	2,425.6
South Ponil Creek	713.2	51.2	81.6	268.4	185.5	126.5
Ute Creek-Cimarron River	1,164.0	149.5	187.7	163.2	368.9	294.7
Total	**36,689.7**	**608.4**	**5,768.2**	**4,637.7**	**12,619.3**	**13,056.0**

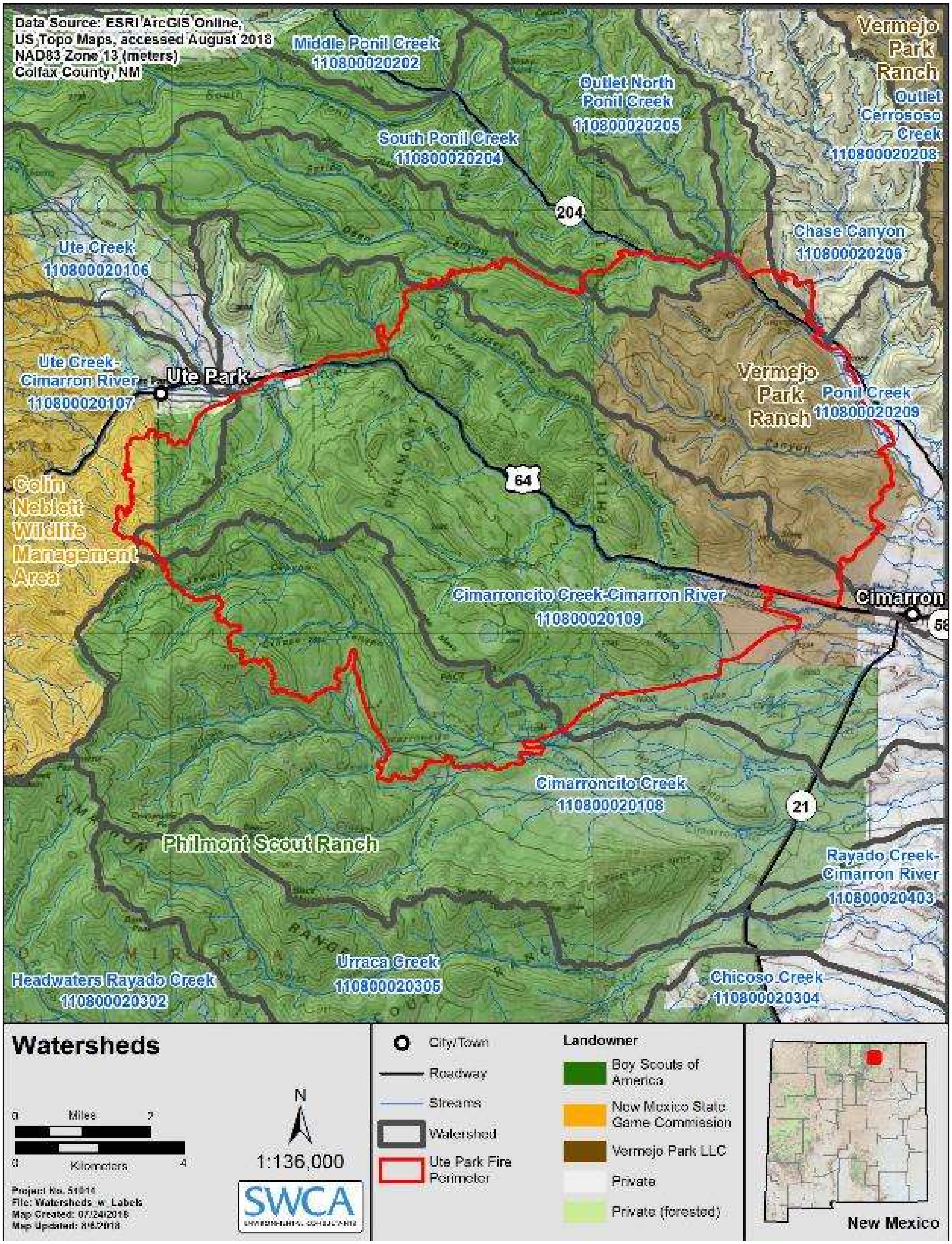

Figure 2.5. HUC 12 Watersheds impacted by the Ute Park Fire.

Major Surface Water and Groundwater Sources

Surface waters impacted by the Ute Park Fire all occurred in Colfax County and lie entirely within the Canadian River Basin. Surface waters supply about 92% of the water currently used in the county and is the primary source of municipal water for Cimarron and Springer. This water primarily originates in the mountains in the western and northern parts of the county and flows generally east and south to the Canadian River, which is a jurisdictional water way. Since the streams within the burned area have potential to be jurisdictional the USACE should be consulted before any work is done below the ordinary high water mark. Surface water availability varies greatly from year to year, depending on the amount of precipitation in the region. Groundwater development is limited; however, it does supply smaller water systems and domestic and livestock wells throughout the burn scar, especially on Philmont Scout Ranch and in the community of Ute Park. Figure 2.6 below shows the major drainages and associated watersheds impacted by the fire.

An important critical value at risk is the surface water that supplies three municipal water systems (the Village of Cimarron, the City of Raton, and the Town of Springer). The water is supplied by releases from Eagle Nest Dam (on the main stem of the Cimarron River) and by three perennial tributaries (Clear Creek, Tolby Creek, and Cimarroncito Creek), along with seasonal flows from Ute Creek. The Village of Cimarron and the City of Raton both have diversions upstream from the Village of Cimarron. Springer obtains its water supply from a diversion through the Springer Ditch system that supplies Springer Lake, which is located west of Springer. Both Cimarron and Raton obtain their primary water supply from other sources, and only use Cimarron diversions as supplemental supplies. During the Track Fire in 2011, the Cimarron River was the primary source of water for Raton, meaning that it is a critical secondary supply source for the area. Ute Creek contributes surface water to the Cimarron River from its headwaters on the east side of the Baldy Mountain complex. Flows along Ute Creek are diverted through a system of ditches that irrigate pastures used during the summer by a sizable local elk herd as well as cattle. Some waters from this area are channeled into pass-through lakes and one reservoir.

Water Quality

In general, before the fire, surface water quality in the region was good, with some impairments as a result of the land management activities in the area and impacts of previous fires, including the Ponil Complex in 2002. The large issues impacting surface waters have been associated with temperature, sediment, and nutrients. A more detailed assessment on the water quality within Colfax County can be found in the 2016 Colfax Regional Water Plan.[4]

[4] Colfax Regional Water Plan: http://www.ose.state.nm.us/Planning/RWP/Regions/09_Colfax/2016/Reg%209_Colfax_Regional%20Water%20Plan%202016_July%202016.pdf

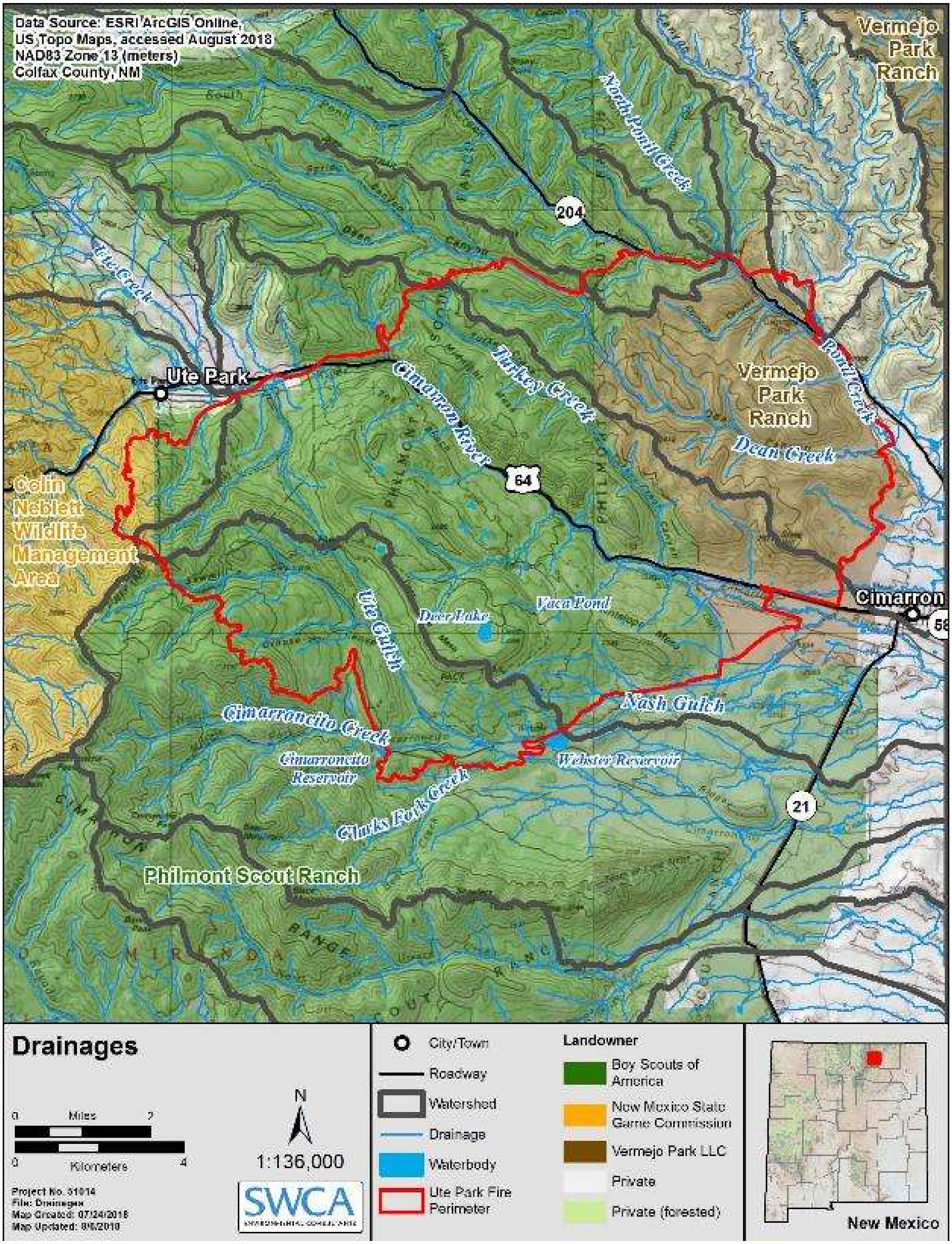

Figure 2.6. Regional drainages impacted as a result of the Ute Park Fire.

VEGETATION/FOREST RESOURCES

Vegetation of the burn area is composed of several major vegetation types that change across an elevation gradient from the lowest elevations on the east side of the burn near the town of Cimarron, to the highest elevations on the west side of the burn area near the community of Ute Park. According to mapping by the Southwest Regional Gap Analysis Project (SWReGAP 2018),[5] the primary vegetation types across that elevation gradient from the lowest elevations on the east side of the burn area include: open grasslands (Western Great Plains Shortgrass Prairie; Western Great Plains Foothill and Piedmont Grassland), that transition upward in elevation into savanna and shrublands (Southern Rocky Mountain Juniper, Woodland and Savanna; Rocky Mountain Gambel Oak-Mixed Montane Shrubland), which continue to transition upward in elevation to pinyon-juniper woodland (Southern Rocky Mountain Pinyon-Juniper Woodland), which transition upward in elevation to ponderosa pine woodland (Rocky Mountain Ponderosa Pine Woodland), and finally to high-elevation mixed conifer woodlands (Rocky Mountain Montane Dry-Mesic Mixed Conifer Forest and Woodland; Rocky Mountain Mesic Montane Mixed Conifer Forest and Woodland; Rocky Mountain Aspen Forest and Woodland) (Table 2.4, Figure 2.7).

Additionally, riparian vegetation (Rocky Mountain Lower Montane Riparian Woodland and Shrubland; SWReGAP 2018) occurs along streams of major drainage bottoms, including the Cimarron River. Acreages for each of those major vegetation types mapped across the burn area are presented in Table 2.4.

Table 2.4. SWReGAP Common Vegetation Community Composition within the Ute Park Burn Perimeter

SWReGAP Class	Acres	Percent of Burn Area
Southern Rocky Mountain Juniper, Woodland and Savanna	202.60	0.5
Rocky Mountain Aspen Forest and Woodland	254.42	0.7
Western Great Plains Foothill and Piedmont Grassland	283.99	0.8
Rocky Mountain Lower Montane Riparian Woodland and Shrubland	453.46	1.2
Rocky Mountain Montane Dry-Mesic Mixed Conifer Forest and Woodland	808.84	2.2
Rocky Mountain Mesic Montane Mixed Conifer Forest and Woodland	1,959.52	5.3
Western Great Plains Shortgrass Prairie	1,965.70	5.4
Rocky Mountain Gambel Oak-Mixed Montane Shrubland	2,415.20	6.6
Southern Rocky Mountain Pinyon-Juniper Woodland	4,985.63	13.5
Rocky Mountain Ponderosa Pine Woodland	22,498.70	61.2

Note: Only vegetation classes with 100 or more acres within the burn area are included in this table.

[5] Southwest Regional Gap Analysis Project, Land Cover Descriptions: http://swregap.nmsu.edu/HMdatabase/landc_database_report.pdf

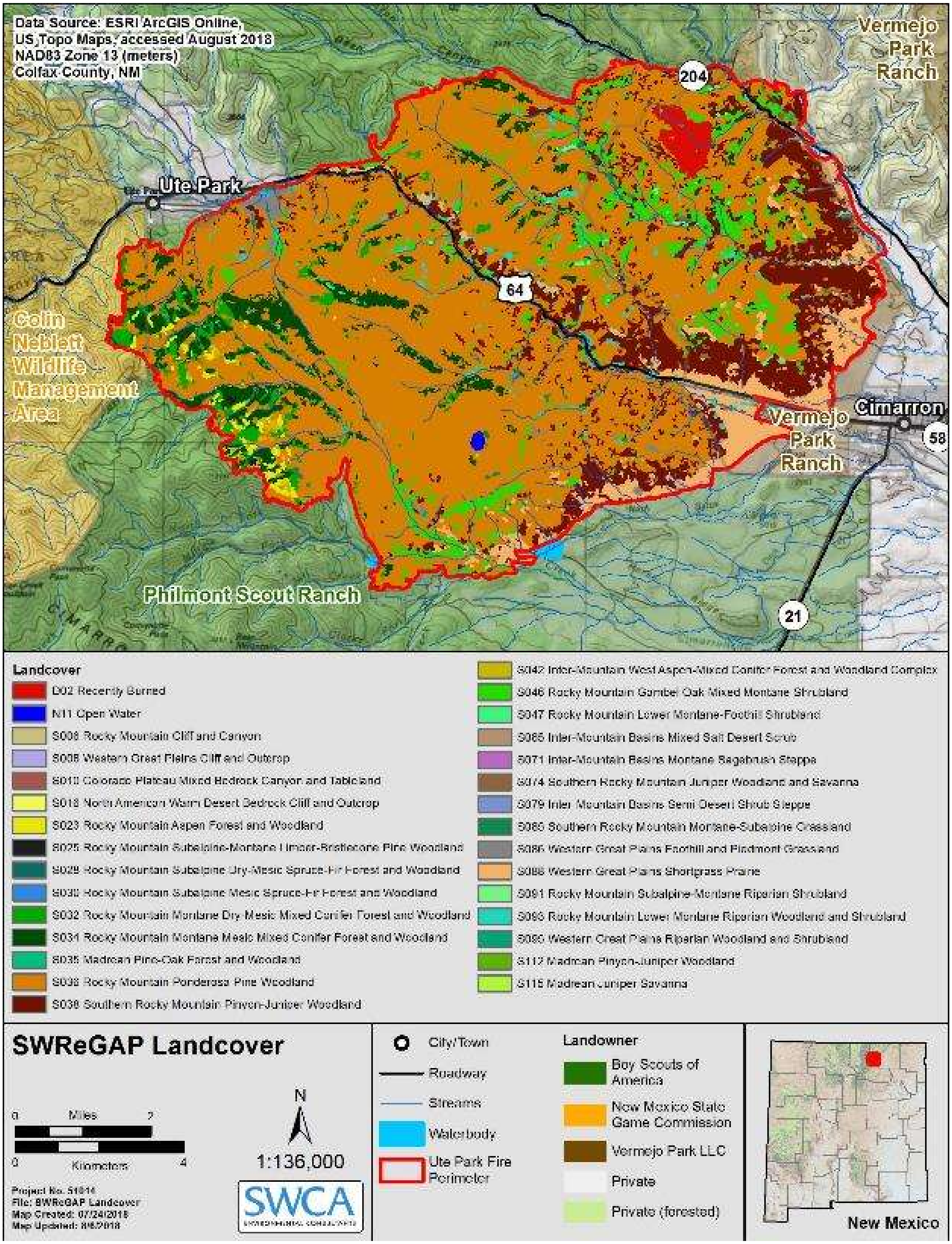

Figure 2.7. Vegetation communities within the Ute Park burn perimeter.

Vegetation Community Descriptions

Vegetation types of the burn area not only change with elevation as stated above, but also with slope and aspect. In general, vegetation types associated with lower elevations are found at higher elevations on south-facing slopes, and vegetation types found at higher elevations, occur at lower elevations on north-facing slopes. That effect of aspect on vegetation is further enhanced by slope steepness.

Dick-Peddie (1993) provides similar natural vegetation classifications, and also provides information on the plant species compositions, historical status of the vegetation types, and ecology and successional series of plant species associated with these major vegetation types following disturbance such as wildfire. Refer to Dick-Peddie (1993) for information on how these vegetation communities respond to wildfire.

Grassland/Herbaceous Communities

WESTERN GREAT PLAINS FOOTHILL AND PIEDMONT GRASSLAND (0.8% OF THE BURNED AREA)

This community occurs between 5,200 and 7,200 feet in elevation on moderate to gentle slopes. It is mostly characterized as mixed-grass to tallgrass prairie in a narrow elevational band between montane woodlands and shrublands and shortgrass steppe. Usually occurrences of this system have multiple plant associations that may be dominated by *Andropogon gerardii*, *Schizachyrium scoparium*, *Muhlenbergia montana*, *Nassella viridula*, *Pascopyrum smithii*, *Sporobolus cryptandrus*, *Bouteloua gracilis*, *Hesperostipa comata*, or *Hesperostipa neomexicana* (SWReGAP 2018). Dick-Peddie (1993) classified this grassland vegetation type as Plains-Mesa Grassland, and states that the open nature of these grasslands were historically maintained by frequent low-severity wildfire.

WESTERN GREAT PLAINS SHORT GRASS PRAIRIE (5.4% OF THE BURNED AREA)

This community occurs primarily on flat to rolling uplands with loamy soils. Blue grama grass (*Bouteloua gracilis*) dominates the system, with common species also including *Aristida purpurea*, *Bouteloua curtipendula*, *Bouteloua hirsuta*, *Buchloe dactyloides*, *Hesperostipa comata*, and *Koeleria macrantha*. Sod-forming short grasses are dominant. In contrast to other prairie systems, fire is less important in this vegetation community, especially in the western range of this system, because the often dry and xeric climate conditions can decrease the fuel load and thus the relative fire frequency within the system. However, historically, fires that did occur were often very expansive. The short grasses that dominate this system are extremely drought- and grazing-tolerant. These species evolved with drought and large herbivores and, because of their stature, are relatively resistant to overgrazing (SWReGAP 2018). Dick-Peddie (1993) classified this grassland vegetation type as Plains-Mesa Grassland, and states that the open nature of these grasslands were historically maintained by frequent low-severity wildfire.

Riparian Communities

ROCKY MOUNTAIN LOWER MONTANE RIPARIAN WOODLAND AND SHRUBLAND (1.2% OF THE BURNED AREA)

Found at elevations from 2,900 to 9,100 feet, this community often occurs as a mosaic of multiple communities that are tree-dominated with a diverse shrub component. This system is dependent on a natural hydrologic regime, especially annual to episodic flooding. Dominant trees may include *Acer negundo*, *Populus angustifolia*, *Populus balsamifera*, *Populus deltoides*, *Populus fremontii*, *Pseudotsuga* *menziesii*, *Picea pungens*, *Salix amygdaloides*, or *Juniperus scopulorum*. Dominant shrubs include *Acer glabrum*, *Alnus incana*, *Betula occidentalis*, *Cornus sericea*, *Crataegus rivularis*, *Forestiera pubescens*, *Prunus virginiana*, *Rhus trilobata*, *Salix monticola*, *Salix drummondiana*, *Salix exigua*, *Salix irrorata*, *Salix lucida*, *Shepherdia argentea*, or *Symphoricarpos* spp. Exotic trees of *Elaeagnus angustifolia* and *Tamarix* spp. are common in some stands (SWReGAP 2018). Dick-Peddie (1993) classified this vegetation type as Montane Riparian, and provides detailed information on how plant species compositions change across elevation gradients.

Shrubland Communities

ROCKY MOUNTAIN GAMBEL OAK-MIXED MONTANE SHRUBLAND (6.6% OF THE BURNED AREA)

These shrublands are most commonly found along dry foothills, lower mountain slopes, and at the edge of the western Great Plains from approximately 6,500 to 9,500 feet in elevation, and are often situated above pinyon-juniper woodlands. The vegetation is typically dominated by *Quercus gambelii* alone or codominant with *Amelanchier alnifolia*, *Amelanchier utahensis*, *Artemisia tridentata*, *Cercocarpus montanus*, *Prunus virginiana*, *Purshia stansburiana*, *Purshia tridentata*, *Robinia neomexicana*, *Symphoricarpos oreophilus*, or *Symphoricarpos rotundifolius*. Density and cover of *Quercus gambelii* and *Amelanchier* spp. often increase after fire (SWReGAP 2018). In addition to Gambel oak, gray oak (*Quercus grisea*) also was common in lower elevations of the Ute Park Fire burn area. Dick-Peddie (1993) classified this vegetation as Montane Scrub, and noted how it tends to be a climax vegetation type on drier sites among woodlands and forests, typically on steep south-facing slopes.

Woodland Communities

SOUTHERN ROCKY MOUNTAIN JUNIPER, WOODLAND AND SAVANNAH (0.5% OF THE BURNED AREA)

This community occurs along east and south slopes, just below the lower elevational range of ponderosa pine and often intermingles with grasslands and shrublands. The vegetation type is savannah in appearance with widely spaced mature juniper trees and occasionally *Pinus edulis*. *Juniperus monosperma* and *Juniperus scopulorum* (at higher elevations) are the dominant tall shrubs or trees. Graminoid species are similar to those found in Western Great Plains Shortgrass Prairie, with *Bouteloua gracilis* and *Pleuraphis jamesii* being most common. In addition, succulents such as species of *Yucca* and *Opuntia* are typically present (SWReGAP 2018). Dick-Peddie (1993) classified this vegetation type as Juniper Savannah, and noted that juniper has increased considerably in these areas due to the lack of natural wildfire and extensive livestock grazing.

ROCKY MOUNTAIN ASPEN FOREST AND WOODLAND (0.7% OF THE BURNED AREA)

Found at elevations ranging from 5,000 to 10,000 feet, the distribution of the community is primarily limited by adequate soil moisture. The vegetation community is dominated by *Populus tremuloides* without a significant conifer component. The understory structure may be complex with multiple shrub and herbaceous layers, or simple with just an herbaceous layer. The herbaceous layer may be dense or sparse, dominated by graminoids or forbs. Associated shrub species include *Symphoricarpos* spp., *Rubus parviflorus*, *Amelanchier alnifolia*, and *Arctostaphylos uva-ursi*. Occurrences of this system originate and are maintained by stand-replacing disturbances such as avalanches, crown fire, insect outbreak, disease and windthrow, or clearcutting by man or beaver, within the matrix of conifer forests (SWReGAP 2018). Dick-Peddie (1993) classified this vegetation type as Aspen Disturbance Forest, and stated that this type of vegetation is early successional to mid-successional, resulting largely from high-severity wildfire eliminating conifer trees at high elevations.

SOUTHERN ROCKY MOUNTAIN PINYON JUNIPER WOODLAND (13.5% OF THE BURNED AREA)

These woodlands occur on warm, dry sites on mountain slopes, mesas, plateaus, and ridges. Severe climatic events occurring during the growing season, such as frosts and drought, are thought to limit the distribution of pinyon-juniper woodlands to relatively narrow altitudinal belts on mountainsides. *Juniperus scopulorum* may codominate or replace *Juniperus monosperma* at higher elevations. Understory layers are variable and may be dominated by shrubs, graminoids, or be absent. Associated species are more typical of southern Rocky Mountains than the Colorado Plateau and include *Artemisia bigelovii*, *Cercocarpus montanus*, *Quercus gambelii*, *Achnatherum scribneri*, *Bouteloua gracilis*, *Festuca arizonica*, or *Pleuraphis jamesii* (SWReGAP 2018). Dick-Peddie (1993) classified this vegetation type as Pinyon-Juniper Woodland, and noted that these woodlands have increased in New Mexico due to a reduction in grassland and savanna wildfire frequency.

Forested Communities

SOUTHERN ROCKY MOUNTAIN PONDEROSA PINE WOODLAND (61.2% OF THE BURN AREA)

These woodlands occur at the lower tree line/ecotone between grassland or shrubland and more mesic coniferous forests, typically in warm, dry, exposed sites. They are typically found around elevations up to 9,000 feet. Occurrences are found on all slopes and aspects; however, moderately steep to very steep slopes or ridgetops are most common. *Pinus ponderosa* (primarily var. *scopulorum* and var. *brachyptera*) is the predominant conifer; *Pseudotsuga menziesii*, *Pinus edulis*, and *Juniperus* spp. may be present in the tree canopy. The understory is usually shrubby, with *Artemisia nova*, *Artemisia tridentata*, *Arctostaphylos patula*, *Arctostaphylos uva-ursi*, *Cercocarpus montanus*, *Purshia stansburiana*, *Purshia tridentata*, *Quercus gambelii*, *Symphoricarpos oreophilus*, *Prunus virginiana*, *Amelanchier alnifolia*, and *Rosa* spp. common species. *Pseudoroegneria spicata* and species of *Hesperostipa*, *Achnatherum*, *Festuca*, *Muhlenbergia*, and *Bouteloua* are some of the common grasses. Mixed fire regimes and ground fires of variable return intervals maintain these woodlands, depending on climate, degree of soil development, and understory density (SWReGAP 2018). Dick-Peddie (1993) classified this vegetation type as a subunit of Lower Montane Coniferous Forest; several different ponderosa pine series, and noted that ponderosa pine woodlands are fire adapted and the natural open-stand structure of ponderosa pine woodland was historically maintained by frequent, low-severity surface fire.

ROCKY MOUNTAIN MONTANE DRY-MESIC MIXED CONIFER FOREST AND WOODLAND (2.2% OF THE BURNED AREA)

These are mixed-conifer forests occurring on all aspects, at elevations ranging from 4,000 to 11,000 feet. The composition and structure of overstory is dependent upon the temperature and moisture relationships of the site, and the successional status of the occurrence. *Pseudotsuga menziesii* and *Abies concolor* are most frequent, but *Pinus ponderosa* may be present to codominant. A number of cold-deciduous shrub and graminoid species are common, including *Arctostaphylos uva-ursi*, *Mahonia repens*, *Paxistima myrsinites*, *Symphoricarpos oreophilus*, *Jamesia americana*, *Quercus gambelii*, and *Festuca arizonica*. This system was undoubtedly characterized by a mixed severity fire regime in its "natural condition," characterized by a high degree of variability in lethality and return interval (SWReGAP 2018). Dick-Peddie (1993) classified this vegetation type as Upper Montane Coniferous Forest, composed of different subunit series based on dominant conifer tree species, and that these forests have become severely overgrown from wildfire suppression over the past century.

ROCKY MOUNTAIN MESIC MONTANE MIXED CONIFER FOREST AND WOODLAND (5.3% OF THE BURNED AREA)

This community occurs predominantly in cool ravines and on north-facing slopes, at elevations ranging from 4,000 to 11,000 feet. Occurrences of this system are found on cooler and more mesic sites than Rocky Mountain Montane Dry-Mesic Mixed Conifer Forest and Woodland. *Pseudotsuga menziesii* and *Abies concolor* are most common canopy dominants, but *Picea engelmannii*, *Picea pungens*, or *Pinus ponderosa* may be present. This system includes mixed conifer/*Populus tremuloides* stands. A number of cold-deciduous shrub species can occur. Herbaceous species include *Bromus ciliatus*, *Carex geyeri*, *Carex rossii*, *Carex siccata*, *Muhlenbergia virescens*, *Pseudoroegneria spicata*, *Erigeron eximius*, *Fragaria virginiana*, *Luzula parviflora*, *Osmorhiza berteroi*, *Packera cardamine*, *Thalictrum occidentale*, and *Thalictrum fendleri*. Naturally occurring fires are of variable return intervals, and mostly light, erratic, and infrequent due to the cool, moist conditions (SWReGAP 2018). Dick-Peddie (1993) classified this vegetation type as Upper Montane Coniferous Forest, composed of different subunit series based on dominant conifer tree species, and that these forests have become severely overgrown from wildfire suppression over the past century.

FUEL TYPE

Vegetation in the burn area can be classified using fire behavior fuel models which predict the potential fire behavior and effects of wildland fire. Using the Scott and Burgan 40 fuel model classification (Scott and Burgan 2005), the following fuel model types are common within the burn area (Table 2.5).

Table 2.5. Common Fuel Model Types Found within the Ute Park Burn Perimeter

Scott and Burgan Fuel Model	Description	Similar Anderson Fuel Model
GR1: Short sparse dry climate grass	Grass is short and/or discontinuous naturally or as a result of grazing. Spread rate is moderate (5–20 chains/hour (ch/hr), flame lengths are low (1–4 feet).	1, Short grass
GR2: Low load dry climate grass	Short grass with greater loading and continuity than GR1. Spread rate is high (20–50 ch/hr), flame length is moderate (4–8 feet).	1, Short grass 2, Timber grass and understory
GS2: Moderate load dry climate grass-shrub	The grass load is moderate and shrub height is 1–3 feet, producing high spread rates (20–50 ch/hr) and moderate flame lengths (4–8 feet).	2, Timber grass and understory
TL3: Moderate load conifer litter	Moderate loads of conifer litter and some coarse woody fuels produce very low spread rates (0–2 ch/hr) with low flame lengths (1–4 feet).	8, Compact timber litter
TL8: Long-needle litter	Long-needle pine litter produce moderate spread rates (5–20 ch/hr) and low flame lengths (1–4 feet).	9, Hardwood or long needle litter
TU1: Timber overstory, grass/shrub understory	Low load grass fuel bed, spread rate low (2–5 ch/hr), flame length low (1–4 feet).	10, Timber understory
TU5: Very high load dry climate timber-shrub	The heavy forest litter and shrub understory is the primary carrier of fire. Spread rates are moderate (5–20 ch/hr), and flame length are moderate (4–8 feet).	10, Timber litter and understory

Source: Scott and Burgan (2005).

WEATHER SUMMARY

The burn area had been experiencing exceptional drought during the week the Ute Park Fire ignited, as seen in Figure 2.8.

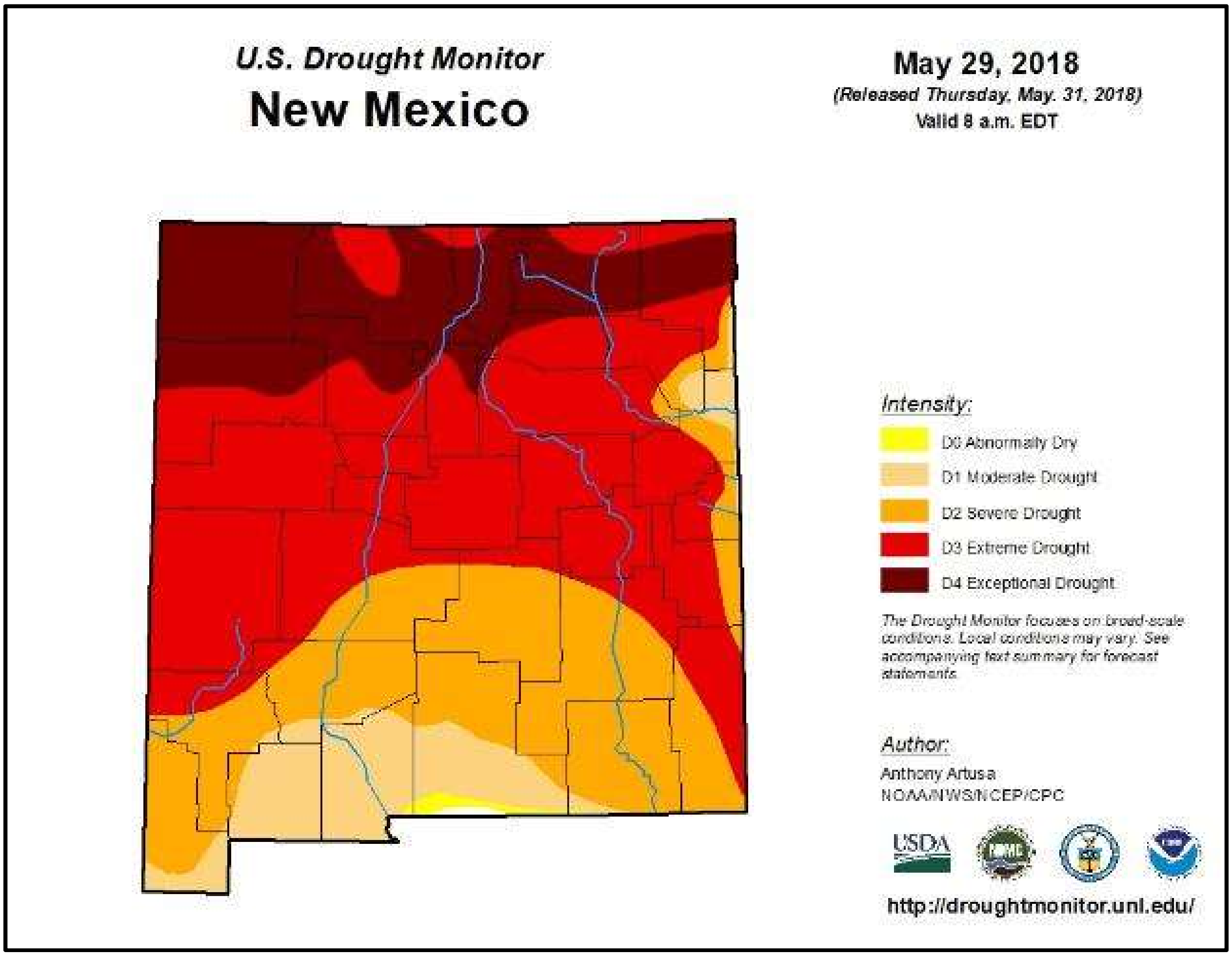

Figure 2.8. Drought map for New Mexico, week of May 29, 2018, showing exceptional drought for Colfax County and the Ute Park burn area.

As seen in Figure 2.9 and Table 2.6, there was minimal precipitation recorded by the Cimarron Remote Automated Weather (RAW) station (RAW 290401) throughout May and June 2018. According to anecdotal accounts, the burn area had received only 2 inches of rain since October 2017, meaning that fuels were exceptionally dry and primed for combustion.

Table 2.6. Monthly Weather Averages during May and June in the Ute Park Fire Area

Date	Average Wind Speed (mph)	Maximum Wind Speed (mph)	Mean Air Temperature (degrees Fahrenheit)	Mean Fuel Moisture (%)	Relative Humidity (%)	Total Precipitation (inches)
May 2018	4.4	6.6	55.1	7.9	32.7	0.40
June 2018	4.4	6.4	65.0	6.8	30.3	0.48

Figure 2.9 and Figure 2.10 show recorded precipitation and air temperatures for the area, beginning on May 1 through to July 2018, relative to average data recorded for the period 2003–2018.

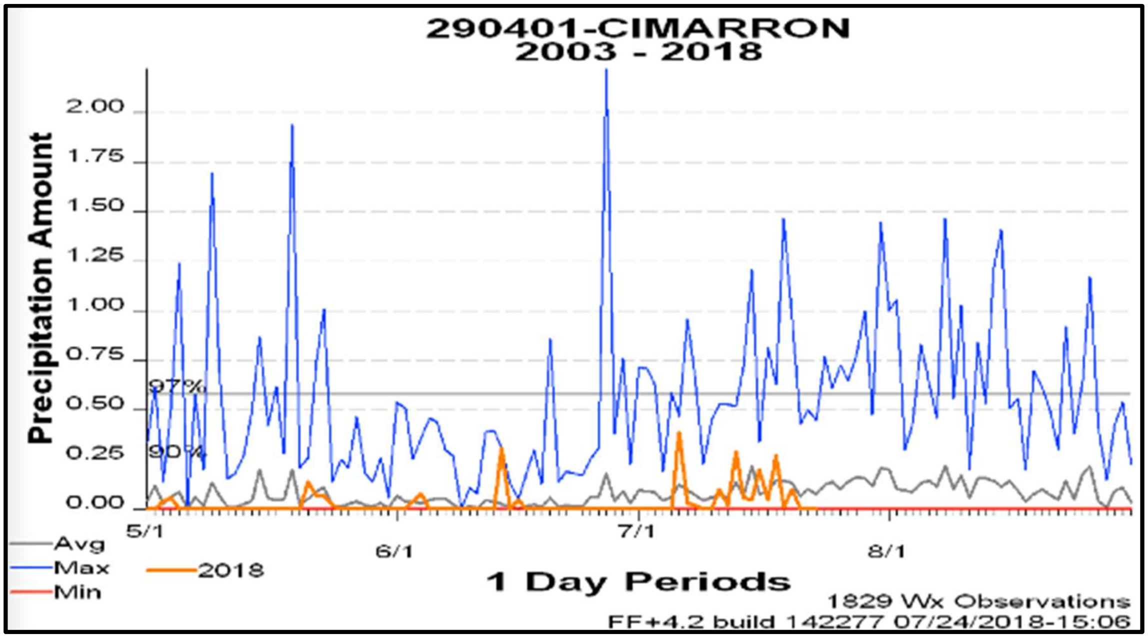

Figure 2.9. Cimarron RAW station precipitation data May 1 to present, relative to average, min and max data from 2003–2018. Graph shows that during the Ute Park Fire (May 31–June 17) precipitation amounts were well below average totals recorded over the last 15 years.

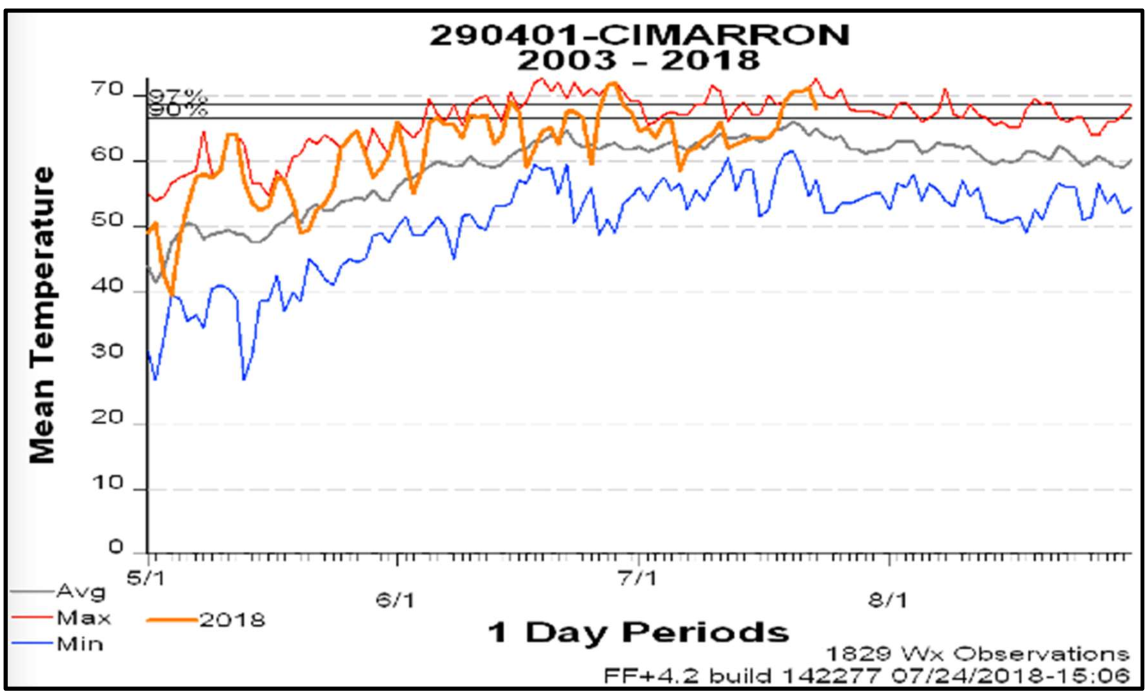

Figure 2.10. Cimarron RAW station mean temperature data May 1–present, relative to average, min and max data from 2003–2018. Graph shows that during the Ute Park Fire (May 31–June 17) air temperatures hovered close to maximum average temperatures recorded over the last 15 years.

Fuel Moistures

Dead fuel moisture readings from the Cimarron RAW station showed extreme low fuel moistures during May and June 2018 (Figure 2.11 and Figure 2.12). Dead fuel moisture responds solely to ambient environmental conditions and is critical in determining fire potential; fuel moisture is classed by time lag, which is loosely defined as "the time it takes a fuel particle to reach 2/3's of its way to equilibrium with its local environment" (Wildland Fire Assessment 2018).[6] In general, drier fuels increase fire spread rate, fireline intensity, and fuel consumption. Fire effects are therefore more severe during periods of extreme low fuel moisture. The most extreme conditions are observed when larger woody materials have below-average fuel moisture, because this shows there has been a prolonged period of drying in the region.

Dead fuel moistures in the Ute Park area hovered around the 97th percentile during the period that the Ute Park Fire burned. Data for 1-hour (woody material less than ¼-inch diameter) and 1,000-hour (3- to 8-inch-diameter woody material) fuels are presented below (see Figure 2.11 and Figure 2.12) in order to demonstrate the extreme fuel conditions that contributed to intense fire behavior and severe fire effects observed on the fire.

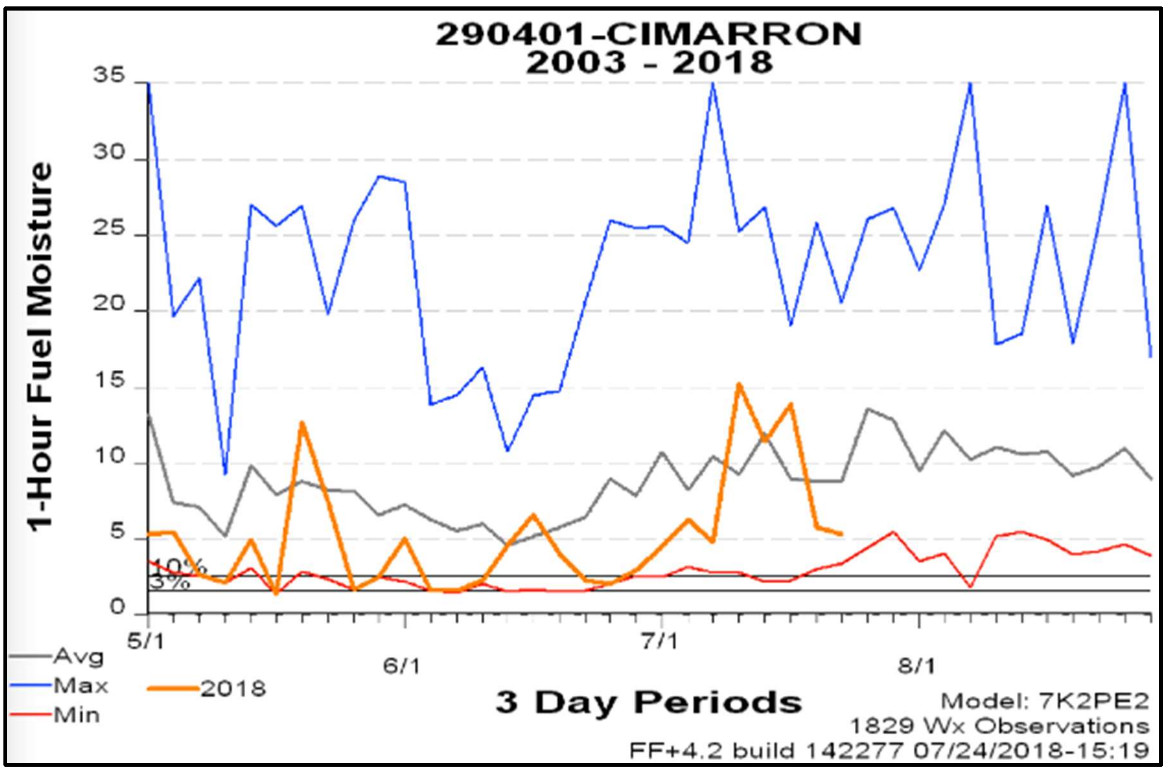

Figure 2.11. One-hour fuel moistures from period May 1, 2018, to current, relative to average, min and max levels (2003–2018). Graph shows the below-average fuel moistures (around the 90th and 97th percentile) in fine fuels in the region at the time the fire was ignited (May 31) through containment (June 17). These conditions are indicative of rapid spread rates.

[6] Dead fuel moisture classes: https://www.wfas.net/index.php/dead-fuel-moisture-moisture--drought-38

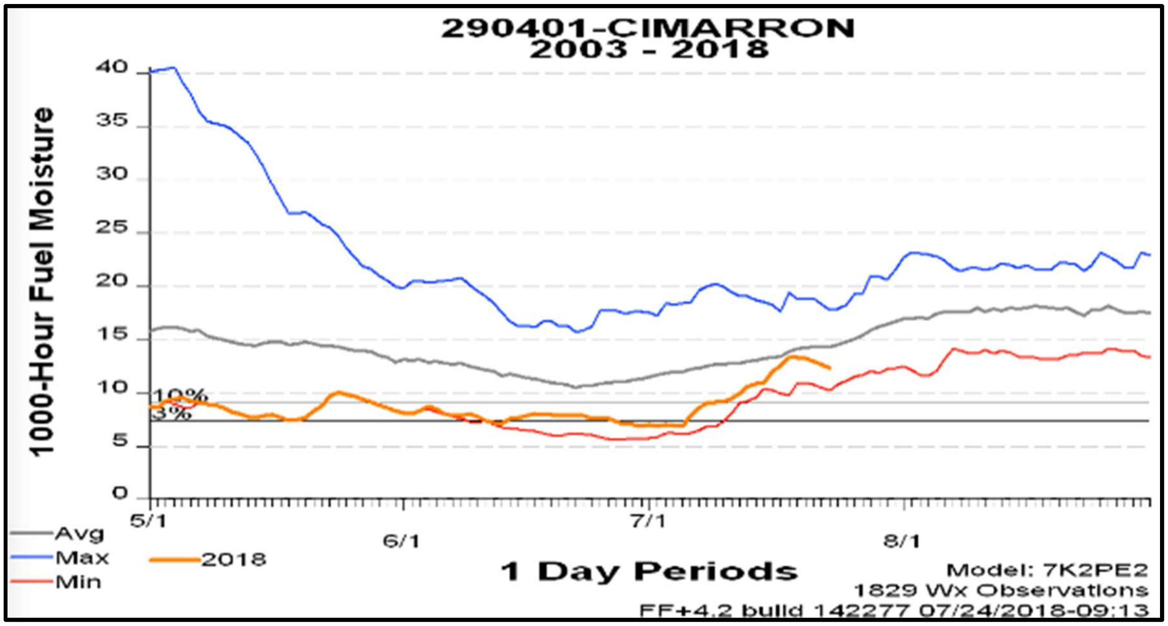

Figure 2.12. One thousand-hour fuel moistures from period May 1, 2018, to current, relative to average, min and max levels (2003–2018). Graph shows the extreme low fuel moistures (around the 97th percentile) in larger woody debris in the region at the time the fire was ignited (May 31) through containment (June 17). These conditions are indicative of high levels of fuel consumption and high fireline intensity.

Fire Regime

The vegetation communities in the burn area exhibit a range of fire regimes (Figure 2.13). A fire regime characterizes the spatial and temporal patterns and ecosystem impacts of fire on the landscape (Fire Regimes2018).[7] Fire regimes have been classified into five categories based on frequency and severity: I = frequent (0–35 years), low severity; II = frequent (0–35 years), stand replacement severity; III = 35–100+ years, mixed severity; IV = 35–100+ years, stand replacement severity; and V = 200+ years, stand replacement severity (National Wildfire Coordinating Group 2006).[8] The two most important factors for determining fire regimes are vegetation type (or ecosystem) and weather and climate patterns.

The majority of the burn area comprises ponderosa pine forest, with dry-mixed conifer at higher elevations. These forest types are characterized by a Fire Regime Group III, which means that fires occurring within those vegetation communities would historically have burned with a frequent, low-severity fire regime, meaning that the vegetation would naturally burn at intervals of less than 35 years, with low-severity fire effects to the understory and overstory vegetation. This would historically have maintained an open park-like forest, with prolific understory of grass and herbaceous species which would carry fire on the surface. Because of current dense stand conditions, prevailing drought, and resulting low fuel moistures, fire behavior during the Ute Park Fire was observed to be high in these ponderosa pine and dry mixed conifer fuels, and the majority burned with uncharacteristic crown fire spread, resulting in moderate to high severity, and stand replacement across large areas.

[7] Fire Regimes: https://www.firescience.gov/projects/09-2-01-9/supdocs/09-2-01-9_Chapter_3_Fire_Regimes.pdf

[8] NWCG Fire Regime Groups: https://www.nwcg.gov/term/glossary/fire-regime-groups%C2%A0

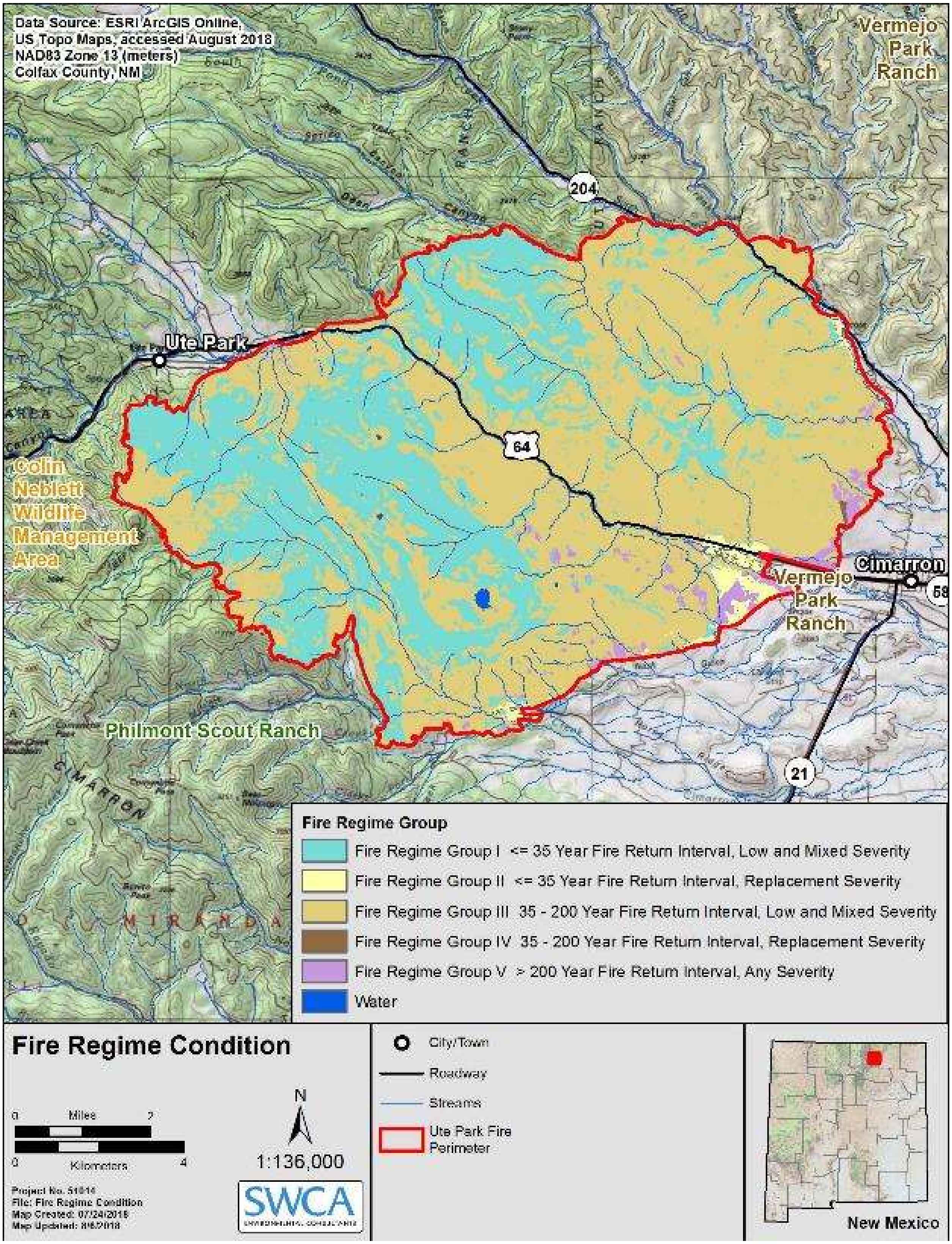

Figure 2.13. Fire regime of vegetation communities within the burn perimeter.

Pinyon Juniper Woodland and Savannah is characterized by a more infrequent fire regime (Fire Regime Group I), in which historically fires would occur on intervals from 35 to 200 years, burning with a low to moderate severity depending on fuel and weather conditions. Within the burn area, 33% of the vegetation falls into this fire regime classification, and burn severity within the vegetation community ranged from low to high (Table 2.7).

Table 2.7. Soil Burn Severity by Fire Regime Group

Fire Regime Group	Unburned (acres)	Unburned-Very Low (acres)	Low (acres)	Moderate (acres)	High (acres)	Total (%)
Fire Regime Group I	141.4	688.9	1,353.0	4,520.3	5,493.7	33
Fire Regime Group II	50.9	58.7	208.6	216.8	3.1	<1
Fire Regime Group III	377.6	4,836.2	2,765.6	7,570.9	7,515.3	63
Fire Regime Group IV	5.5	17.1	40.9	28.1	3.1	0
Fire Regime Group V	42.7	145.9	258.8	270.4	35.5	2

INSECT AND DISEASE

A number of insect and disease species are known to occur in the Sangre de Cristo Mountains in Colfax County. During annual aerial surveys completed by New Mexico State Forestry and the U.S. Forest Service, Forest Health Protection, high volumes of the following insect and disease agents were detected.[9] These agents will continue to impact forest health in the project area, which may impact post-fire recovery and resilience of the area to future catastrophic wildfire. Trees that survived the fire may be more susceptible to insect attacks due to weakened condition.

- Western spruce budworm (*Choristoneura occidentalis*)- defoliator of spruce, Douglas-fir, white fir, and corkbark fir trees
- Tiger moth (*Lophocampa ingens*)- feed on ponderosa pine
- Western forest tent caterpillar (*Malacosoma californicum)-* aspen defoliator
- Pinyon needle scale (*Matsucoccus acalyptus*)- feeds on needles, stunts or reduces growth
- Pinyon Ips bark beetle (*Ips confuses*)- causes extensive pinyon mortality
- Pine bark beetle (*Dendroctonus* spp.)- Populations increasing in Colfax County. Kills ponderosa pine, blue spruce, Engelmann spruce, and Douglas-fir.
- Douglas-fir beetle (*Dendroctonus pseudotsugae*)- kills Douglas-fir and white fir
- Spruce beetle (*Dendroctonus rufipennis*)- attacks spruce fir and Douglas-fir in the northern parts of the Sangre de Cristo Mountains
- Dwarf mistletoe (*Arceuthobium* spp.)- common statewide, attacks ponderosa pine, juniper species, Douglas-fir, pinyon pine (Figure 2.14).

[9] EMNRD 2017. New Mexico Forest Health Conditions. Available at: http://www.emnrd.state.nm.us/SFD/FWHPlan/documents/NMForestHealthConditionsReportComplete.pdf

Figure 2.14. Dead Rocky Mountain juniper showing presence of dwarf mistletoe.

CHAPTER 3 POST-FIRE DAMAGE ASSESSMENT AND REHABILITATION MEASURES

The ecosystem response of a fire may include soil erosion, vegetation regeneration, microbial community structure restoration, faunal recolonization, and invasive species introduction (Keeley 2009). This section describes the post-fire conditions of soils, vegetation and hydrologic function observed during field reconnaissance, followed by recommended actions to mitigate adverse impacts from first order (resulting from the fire itself) and second order (indirect impacts of the fire including erosion, flooding and debris flow) fire effects.

BURN SEVERITY

The Ute Park Fire Damage Assessment and Rehabilitation plan is based upon an assessment of burn severity throughout the burn area. Burn severity is a qualitative assessment of the heat pulse directed toward the ground during a fire. It relates to soil heating, large fuel and duff consumption, consumption of the litter and organic layer beneath trees and isolated shrubs, and mortality of buried plant parts (National Wildlfire Coordinating Group [NWCG] 2006). Burn severity can also be applied to the degree of change to overstory vegetation, which is usually determined through burned area reflectance remote sensing.

A map of the soil burn severity was derived from several different data sets based largely on remote sensed imagery from Landsat 30-meter data. The initial step uses a derived radiometric value called the Normalized Burn Ratio (NBR) that is based on reflectance values differenced between pre-and post-fire delta NBR (dNBR) (described below). The dNBR data are compared with a Burned Area Reflectance Classification or Burned Area Reflectance Classification (BARC) map (a satellite-derived data layer of post-fire vegetation condition)[10] (U.S. Forest Service 2018) and further calibrated with on the ground fire effects using ground truthing by a qualified soil scientist. The Ute Park Soil Burn Severity Map (Figure 3.1) was validated by SWCA during field reconnaissance using the Composite Burn Index methodology (described below). Figure 3.1 shows the extent of the severities across the burn scar (note: acres of unburned vegetation are not included in the legend) and was used by all resource specialist in determining critical areas of risk. This information is also used in the post-fire hydrologic analysis.

Normalized Burn Ratio

The NBR was designed to highlight burned areas and estimate burn severity. The NBR is temporally differenced between pre- and post-fire datasets to determine the extent and degree of change detected from burning. Imagery collected before a fire will have very high near infrared band values and very low mid-infrared band values, and imagery collected after a fire will have very low near infrared band values and very high mid-infrared band values. A high NBR value generally indicates healthy vegetation, whereas a low value indicates bare ground and recently burned areas (Table 3.1).

[10] Burned Area Reflectance Classification: https://www.fs.fed.us/eng/rsac/baer/barc.html

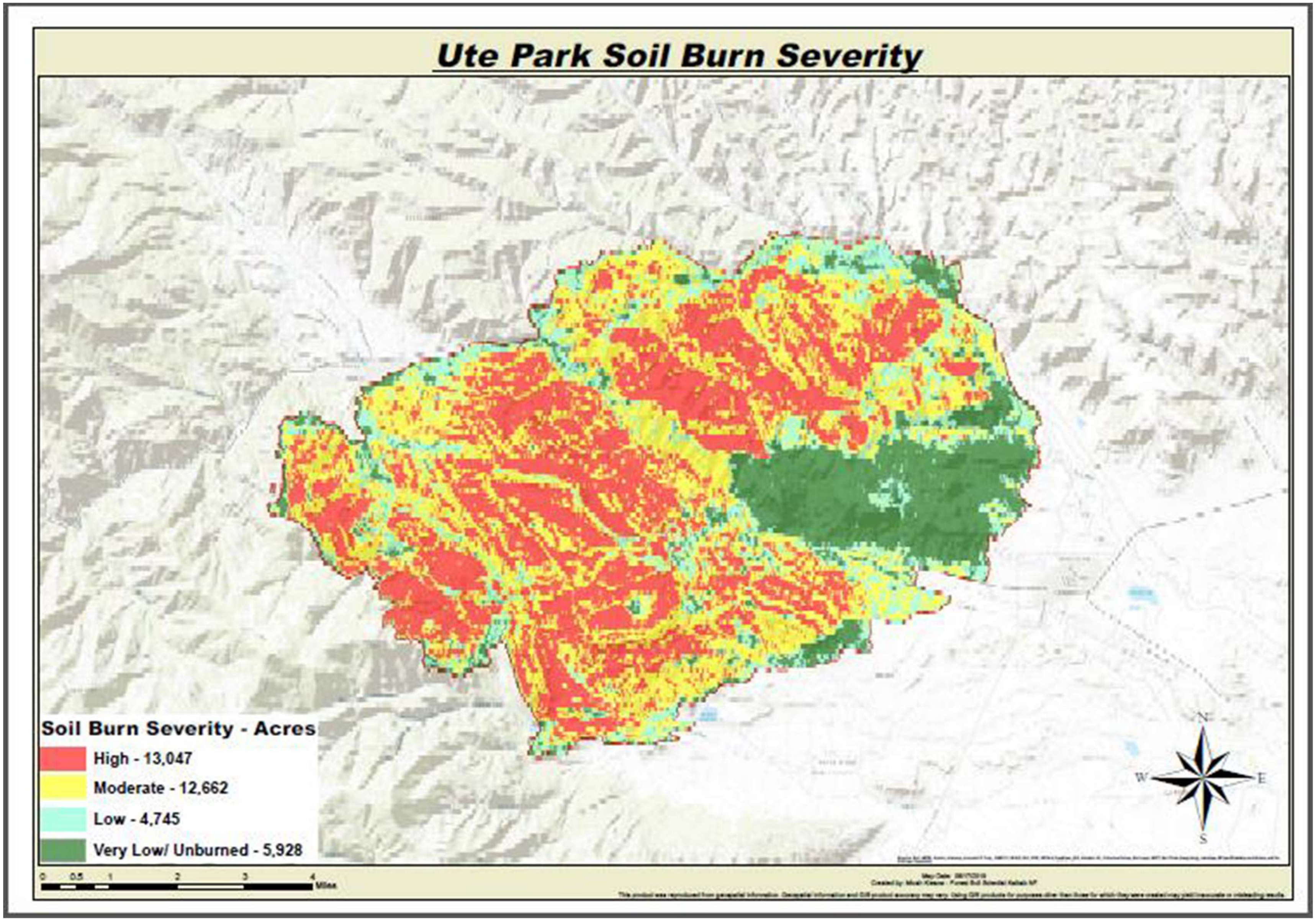

Figure 3.1. Soil burn severity map for the Ute Park Fire. Source: U.S. Forest Service (2018).

$\Delta NBR = PrefireNBR - PostfireNBR$

Table 3.1. Example Interpretation of NBR Difference in Classifying Burn Severity

dNBR	Burn Severity
<-0.25	High post-fire regrowth
−0.25 to −0.1	Low post-fire regrowth
−0.1 to +0.1	Unburned
0.1 to 0.27	Low-severity burn
0.27 to 0.44	Moderate- to low-severity burn
0.44 to 0.66	Moderate- to high-severity burn
>0.66	High-severity burn

Source: Key and Benson (2006).

As shown in Table 3.1, higher dNBR indicate more severe damage. Areas with negative dNBR values may indicate increased vegetation productivity following a fire. Typically, NBR and dNBR images are generated shortly after a fire to get an initial assessment of burn severity and to support fieldwork, as was the case for development of Figure 3.2.

Composite Burn Index

The Composite Burn Index (CBI) is a ground methodology used for classifying post-fire burn severity. The methodology is described in detail in Key and Benson (2006). In this study, the CBI was used in order to ground truth the delta normalized burn ratio (dNBR) data presented in Figure 3.2. The CBI is designed to be applied on a landscape level and it addresses burn severity on a holistic level, such that it represents an aggregate of effects over large areas. With CBI, burn severity is measured three dimensionally, spread over multiple components and strata of the community, which may demonstrate considerable heterogeneity of fire effects. The overall severity can be viewed as the average of that variability (Key and Benson 2006).[11]

CBI field data are collected rapidly, using an ocular estimation and judgement of the degree of change from pre- to post fire conditions. A characteristic of CBI sampling is that average conditions of many factors are considered across multiple strata to derive the severity value for a plot. The approach logically parallels the way Landsat satellite sensors average all features within a pixel to record the multispectral brightness values used to model burn severity (Key and Benson 2006).

The landscape sampling design is hierarchical and multilayered. Each stratum of a vegetative community is evaluated independently by several criteria and given a rating. Scores are decimal values between 0.0 and 3.0, spanning the possible range of severity between unburned and highest burn effect. Scores may be combined (averaged) to yield aggregate CBI ratings for the understory, the overstory, and the total plot (Key and Benson 2006). An example CBI burn severity form is provided in Appendix E.

The CBI scores for plots completed within the Ute Park burn perimeter are mapped in Figure 3.3. It is clear that there is good agreement between the remote sensed classification of burn severity and the ground-based CBI severity scores.

[11] FIREMON Landscape Assessment (Key and Benson 2006): https://www.fs.fed.us/rm/pubs/rmrs_gtr164/rmrs_gtr164_13_land_assess.pdf

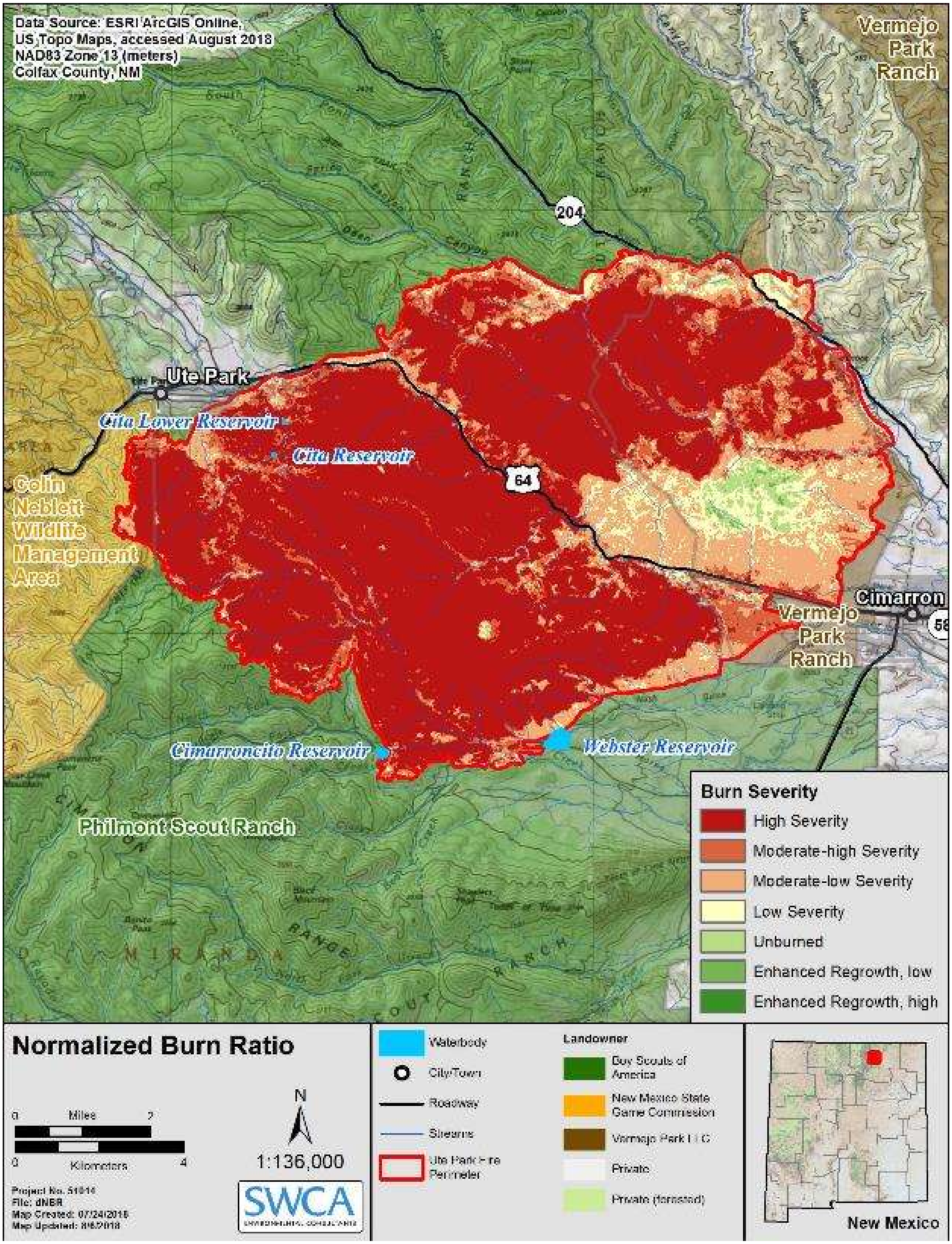

Figure 3.2. dNBR classification for the Ute Park Fire.

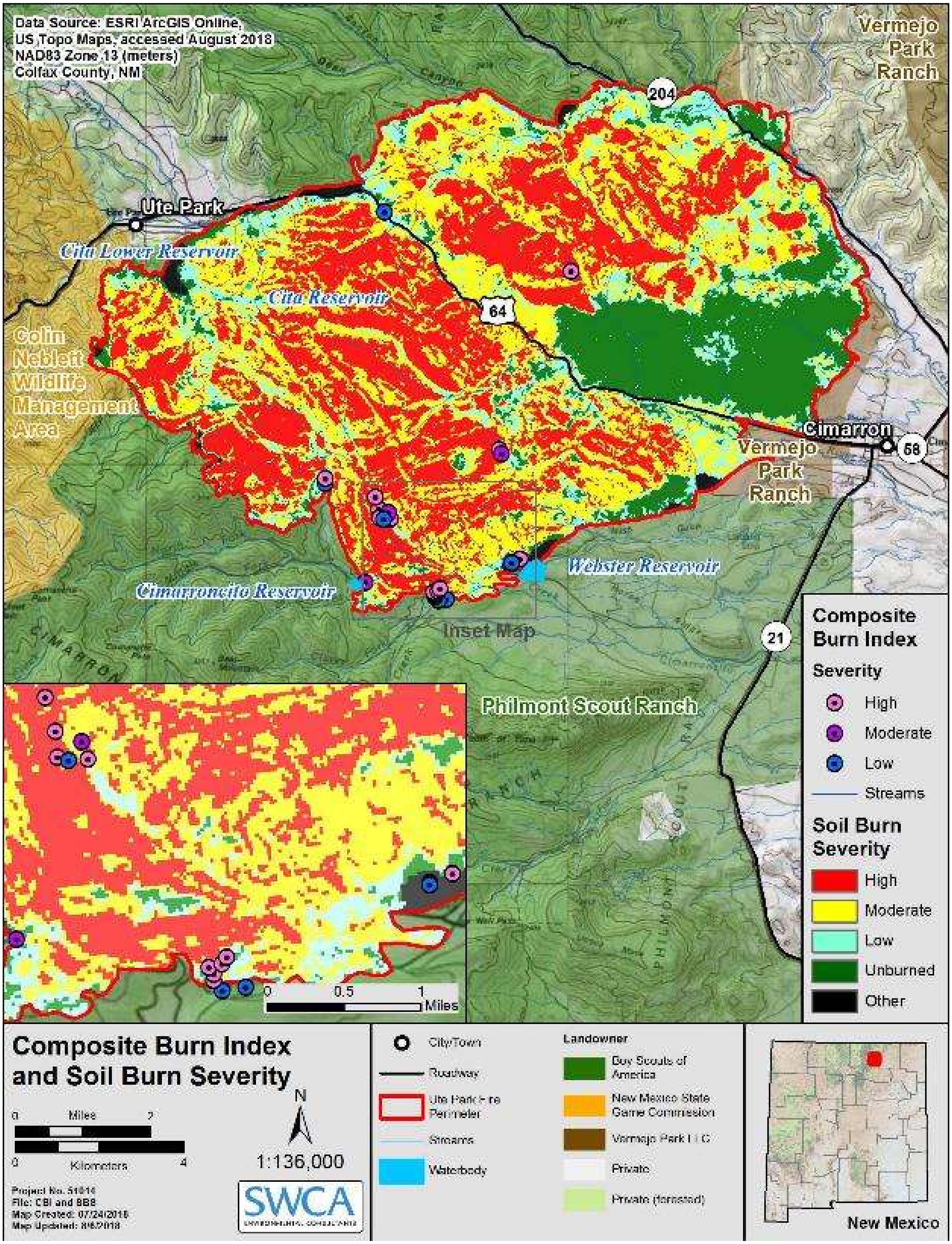

Figure 3.3. CBI scores collected in the field, overlaid on the soil burn severity layer.

CBI also enables the Team to determine the kinds of fire effects that can be expected to be present within each burn severity class, helping to inform proposed rehabilitation measures.

Idaho State University- RECOVER Application

Spatial analysis for this report was supported through data acquisition from the Idaho State University Rehabilitation Capability Convergence for Ecosystem Recovery Program (RECOVER).[12] RECOVER is a GIS web-based application designed to enable fire managers to develop better informed post-fire recovery plans. The SWCA Team was able to acquire large datasets of relevant baseline and post-fire spatial data that were compiled by the RECOVER team to support post-fire emergency rehabilitation work for the Ute Park Burn area. These data sets included:

- Base Layers
    - Fire Boundary
    - Roads
    - National Hydrology Dataset (NHD)
    - Habitat
    - Wetlands (National Wetlands Inventory [NWI])
    - PLSS (Public Land Survey System)
    - SMA (Surface Management Agency)
    - Geology
    - Watersheds
    - Soils (SSURGO, STATSGO, STATSGO_KFactor)
    - Historic Fires
    - Fire regime
    - Elevation, aspect, slope
    - Existing vegetation cover and type
- Landslide Potential
- Debris Flow Probability modeled using USGS protocols
- Fire Affected Vegetation (showing a gradation in the level of impact to vegetation from pre-post fire, based on dNBR [Normalized Burn Ratio]).
- Ecosystem Resilience and Resistance

The RECOVER data products were utilized by the Team during field efforts and they were utilized in analysis and modelling that inform this report.

ENGINEERING AND HYDROLOGY

The changes that wildfire can inflict in a watershed can greatly change its hydrologic response. Several key watershed processes can be significantly altered by wildfire. High temperatures can cause water repellency in soils and consume plant canopy, surface plants and litter, and structure-enhancing organics within soil. Changes in soil moisture, structure, and infiltration can accelerate surface runoff, erosion, sediment transport, and deposition. Intense rainfall and some soil and terrain conditions can contribute to overland runoff, rilling, gullying, and in-channel debris flows. There are a number of naturally existing

[12] RECOVER Program: http://giscenter.isu.edu/research/Techpg/nasa_RECOVER/index.htm

conditions in and around the burn area that make it particularly susceptible to severe secondary fire effects of flooding and debris flow, including intense monsoonal rainfall that occurs throughout July and August, following the typical fire season for New Mexico, and the presence of bare rock outcrops within runoff-generating areas.

Mineralization of organic matter, interruption of root uptake, and loss of shade can impact water quality by increasing stream temperatures and nutrient concentrations. Where wildfires are unnaturally large and severe, negative effects on the watershed are likely. In this region, snowmelt runoff typically generates the highest peak flow in unburned watersheds. On smaller watersheds with large percentages of moderate and high soil burn severity, peak flows can be generated by high intensity rainfall from thunderstorms.

Expected watershed responses include: an initial flush of ash with the first storm events that may allow debris (trees, rocks, etc.) to mobilize easily and move downstream; flash flood events during moderate to high intensity thunderstorms with increased peak flows; rill and gully erosion on slopes in drainages with moderate and high burn severity; and sediment and debris deposition in channels, floodplains, behind road fills, and on alluvial fans. The risk will gradually be reduced over time as vegetation is reestablished and provides ground cover, improves soil stability, and increases surface roughness. Debris flows are also a possible watershed response and are particularly hazardous due to the force of post-fire runoff and mobilization of large amounts of sediment and heavy materials downslope and downstream.

Our assessment of the Ute Park Fire is focused on conducting a reconnaissance-level assessment to stream resources and the anticipated changes to those resources that may result from a disproportional amount of sediment and water caused from the wildfire. The goals of our assessment are to 1) provide a reconnaissance-level analysis of the pre- and post-fire sediment loading and water yield; and 2) develop conceptual treatments to protect stream resources and clean water beneficial uses, including municipal and agricultural water systems and the associated infrastructure that conveys the water (Figure 3.4). Our analysis is not a predictive-level assessment, but a reconnaissance-level to identify issues and develop solutions. Other project partners like the NRCS are conducting more of a predictive-level assessment. The NRCS is in the process of submitting an emergency watershed protection report to the Washington, D.C., office detailing mitigation projects on private lands throughout the burn scar. The NRCS report lays out the treatments, locations, and a time frame to implement. Emergency watershed protection projects following wildfires like the Ute Park Fire are typically implemented before the winter.

Reconnaissance-Level Assessment

Our analysis is intended to be a rapid-level effort to understand and qualify the magnitude of the wildfire damage and watershed response. The impacts from fire on water yield and the variability in watershed characteristics and burn severity, and the role of climate, make it difficult to quantify. Reliable water supply is a critical ecosystem service of forest and rangelands. Our analysis presented herein is our best estimate based on available data and time. A more detailed predictive-level assessment is needed to further evaluate and more accurately predict the post-fire response to stream resources and more clearly understand the long-term threats to clean water beneficial uses. Our analysis provides a framework to continue efforts towards modeling and predicting post-fire wildfire water yield, however results presented herein should be considered rough estimates and order of magnitude ranges.

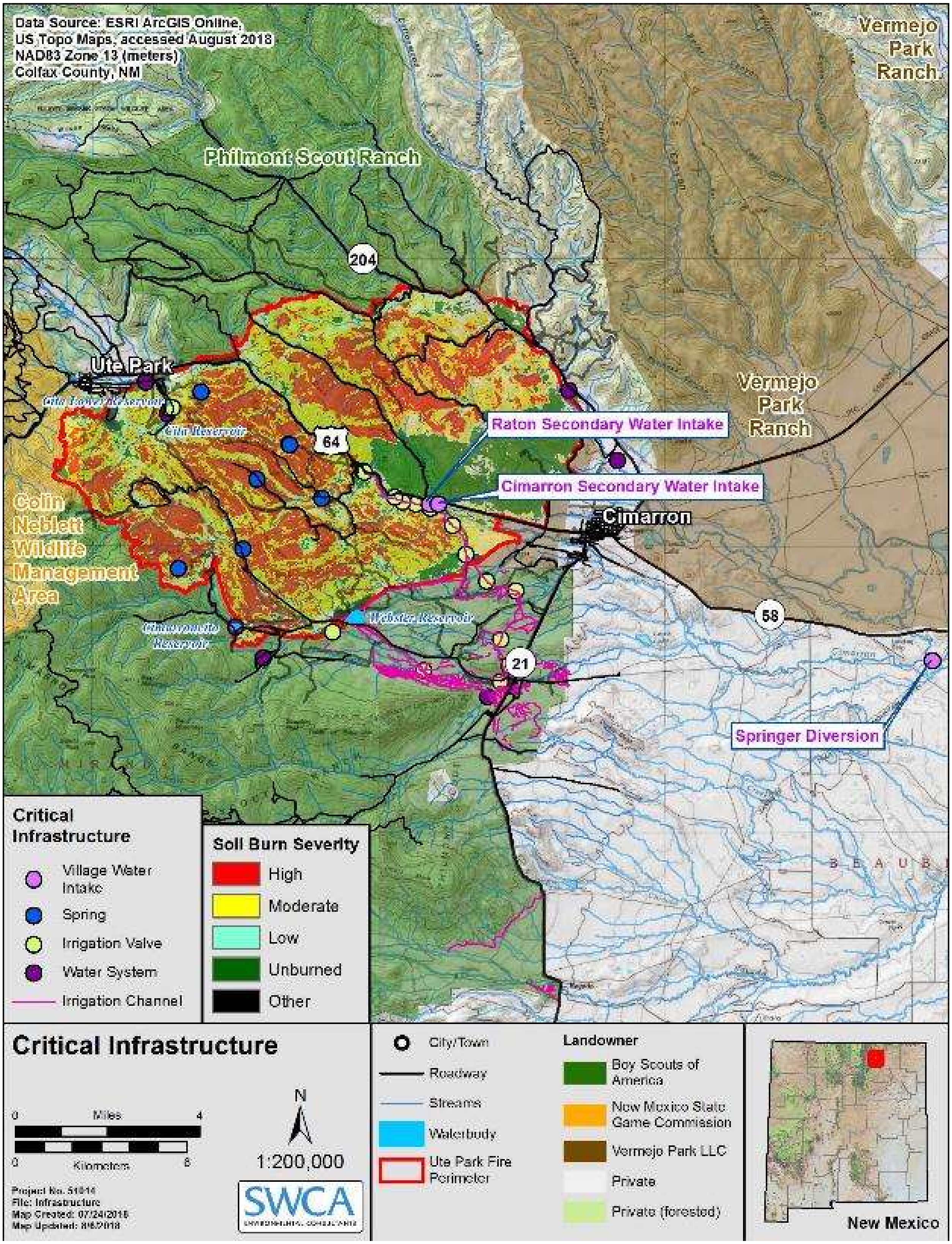

Figure 3.4. Water infrastructure impacted by the Ute Park Fire.

Prior to our field investigation we gathered background information and performed a cursory review of streams and water infrastructure. We developed field maps and prioritized survey sites based on the geomorphic position of streams, and public infrastructure as it relates to the terrain and character of the watershed and the location and extents to burn areas. On July 12 and 13, 2018, a team of engineers and scientists performed a rapid assessment of wildfire damage within the Ute Gulch and Sawmill Gulch, Cimarroncito and Webster Reservoirs, Raton City Secondary Water Supply Diversion, the Cimarron River in the Highway 64 Canyon, and Turkey Creek. Field surveys were performed using GPS survey grade equipment. In addition to damaged areas, we performed stream surveys on the Middle Fork, North Fork and mainstem of the Cimarroncito creeks to collect data for pre-fire reference conditions.

On July 12, 2018, an isolated high-intensity short duration thunderstorm event occurred during our field survey efforts. The thunderstorm produced significant runoff, which temporarily closed U.S. Highway 64. SWCA was able to drive through the Canyon early during the storm event prior to the road closing. Hillslope erosion from moderate and high burn severity areas was evident and numerous gullies were spouting dark, ash-laden water. Our field assessment did not include survey of road culverts and bridges; the USACE performed a reconnaissance-level assessment of critical infrastructure, which included four sites within Cimarron Canyon (Ute Park Wildfire Reconnaissance Report, USACE June 2018). Figures 3.5, Figure 3.6, and Figure 3.7 are images captured along U.S. Highway 64 during the early stages of the rain event.

Figures 3.5. Left: view looking upstream at a gully on the east side of U.S. Highway 64. The gully originates at the high burn severity area in Midnight Mesa. Right: view looking downstream of the gully at the flow being routed by concrete wall barriers to a road culvert.

Figure 3.6. Photograph showing a dark curtain of ash sheet flow on a hillslope on the west side of Cimarron Creek.

Figure 3.7. Photograph showing a gully on the west side of Cimarron Creek that originates from a high burn severity area on the above bench.

On July 12 and 13, 2018, SWCA surveyed the very evident debris flow lines from this storm and included this data with the cross sectional and longitudinal channel surveys. In the high burn severity areas of Ute Gulch and Sawmill Gulch, significant bulk surface erosion had occurred transporting fine sediment and ash. Active debris flow from hillslope erosion was observed across the valley, with multiple flow lines running along old channel terraces and through the burned forest floor. Figure 3.8 through Figure 3.12 depict the sediment-laden flow and general conditions during our field efforts.

Figure 3.8. Looking upstream towards the confluence with Sawmill Gulch (left) and Ute Gulch (right).

Figure 3.9. Looking at the valley floor on the west flank of Ute Gulch downstream of the confluence with Sawmill Gulch. The photograph shows the multiple flow paths and bulk surface erosion transported from the adjacent high burn severity hillslope.

Figure 3.10. Looking at the debris flow across an old Ute Gulch terrace adjacent to the east flank of the valley just upstream of the confluence with Sawmill Gulch. Note that the worker in the yellow shirt is standing over the mainstem of Ute Gulch.

Figure 3.11. Another example of the debris from hillslope runoff transporting across the forest floor. The photograph was taken at a historic terrace bench on the west flank of the valley looking at the Ute Gulch channel.

Figure 3.12. An evident flow line within the Ute Gulch channel located near Ute Springs camp caused from the 0.5-inch rain event that occurred the during field survey efforts.

Turkey Creek was visually assessed downstream of the high burn severity area. The unimproved road was impassible during the time of survey. No GPS survey data were collected. The site was not prioritized for further assessment because of the distance of the high burn severity area to critical clean water sources.

Visual assessment concluded that increased sediment loading caused from the high burn severity area on Midnight Mesa would likely be transported to, and stored within, the channel along the valley floor and not cause a significant sedimentation threat to infrastructure.

Wildfire can disrupt the hydrological cycle in several ways. The formation of an ash layer or hydrophobic layer may inhibit infiltration and reduce lateral flow in the soil, while evapotranspiration can decline as a result from the loss of canopy cover (Hallema et al. 2016). The burn severity of the wildfire has the greatest effect on runoff, as no leaf litter and forest floor storage exist, and the hydrophobic effects of the soils cause faster runoff, which compounds to a much larger volume in the lower drainages.

Increases in annual water yield (runoff from a specified watershed) after wildfires and prescribed fires are highly variable (DeBano et al. 1998; Robichaud et al. 2000a). The increase in runoff rates after wildfires can be attributed to multiple factors and processes. In coniferous forests, like the areas in the Ute Park Fire, the volatilization of organic compounds from the litter and soil can result in a water repellent layer at or near the soil surface (DeBano 2000). The net effect of this water repellent layer is to decrease infiltration, which causes a shift in runoff processes from subsurface lateral flow to overland flow (Campbell et al. 1977; DeBano 2000). The loss of the leaf and debris litter on the forest floor will further reduce infiltration rates.

Fire impacts to peak flows, base flows, and annual water yields can last for years and potentially affect downstream municipal water supplies. A study done on the Willow Wildfire (a low to moderate burn severity fire within pinyon and ponderosa coniferous forest) in the Wetbottom Watershed in Arizona found a 219% increase in water yield during the first 5 years after the fire (Hallema et al. 2016). Ten years after the fire the study demonstrated that the water yield was progressing towards pre-fire conditions. Jarrett (2009) had worked on measuring streamflows on Colorado's Front Range post burn, an approximate 400% increase in post-fire peak flows was observed. According to Jarrett (2009), there have been at least six rainstorms that have exceeded the 100-year precipitation event in the Hayman burn area in the Trail, West, Camp, Horse, Fourmile, and Sixmile Creek basins since the 2002 fire.

Based on our rapid assessment we prioritized six subwatersheds to evaluate for pre- and post-fire water yield which were based on areas that rehabilitation work would have the greatest impact on critical values at risk (see Figure 2.5).

Streams are considered by fluvial geomorphologists to be the barometer of the watershed. If the sediment or water supply rates are increased of decreased this will be translated to the stream channel dimension and profile. An active channel is often marked by active scour and depositional patterns, these active features can be identified during field reconnaissance and are often referred to as Bankfull features (Leopold et al. 1964). Bankfull discharge is the frequent peak flow that fills the channel to the incipient level of flooding and when inundation of the floodplain or flood-prone area occurs. It often associated with a return interval of 1 to 2 years and is coincident with the effective discharge or channel forming flows. Bankfull (Q) was estimated using bankfull stage field indicators with the continuity equation ($Q = A * u$) by estimating mean velocity (u) and calculating the bankfull cross-sectional area (XSA). The calculated bankfull discharge was then compared to regional curves developed for this project representing bankfull discharge vs. drainage area. This regional curve is based on calibrated, field-determined bankfull values at USGS stream gages (Moody 2001). Figure 3.13 below shows the New Mexico regional curve relating drainage area to bankfull cross-sectional area (XSA) overlaid with our field survey data of representative reaches with the subwatersheds.

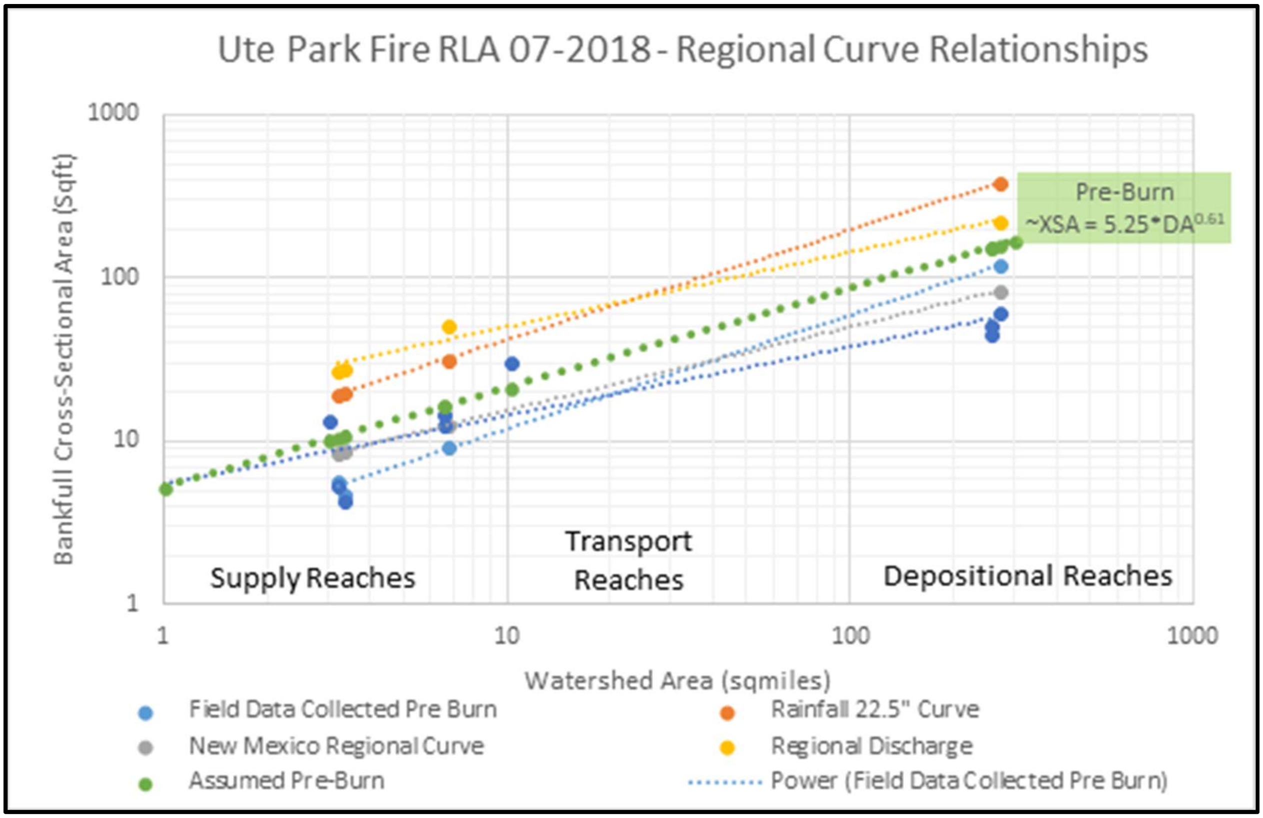

Figure 3.13. Ute Park Fire regional curve relating drainage area with bankfull cross-sectional area.

During the RLA the river assessment team evaluated the depositional features and erosional features in the field to infer the processes of excess supply and excess deposition due to watershed characteristic changes after the burn. A thunderstorm on July 12, 2018, may have been approximately 0.5-inch magnitude, as measured at a visual rain gauge at a Philmont ranch site in the Ute Gulch area, based on personal communication. An example cross-section is shown in Figure 3.14, which depicts the bankfull XSA and shows the XSA measured from debris flow lines from the 0.5-inch rainfall event. A photograph was taken from the bridge looking towards the cross section, the section was located approximately 40 feet downstream of the bridge (Figure 3.15).

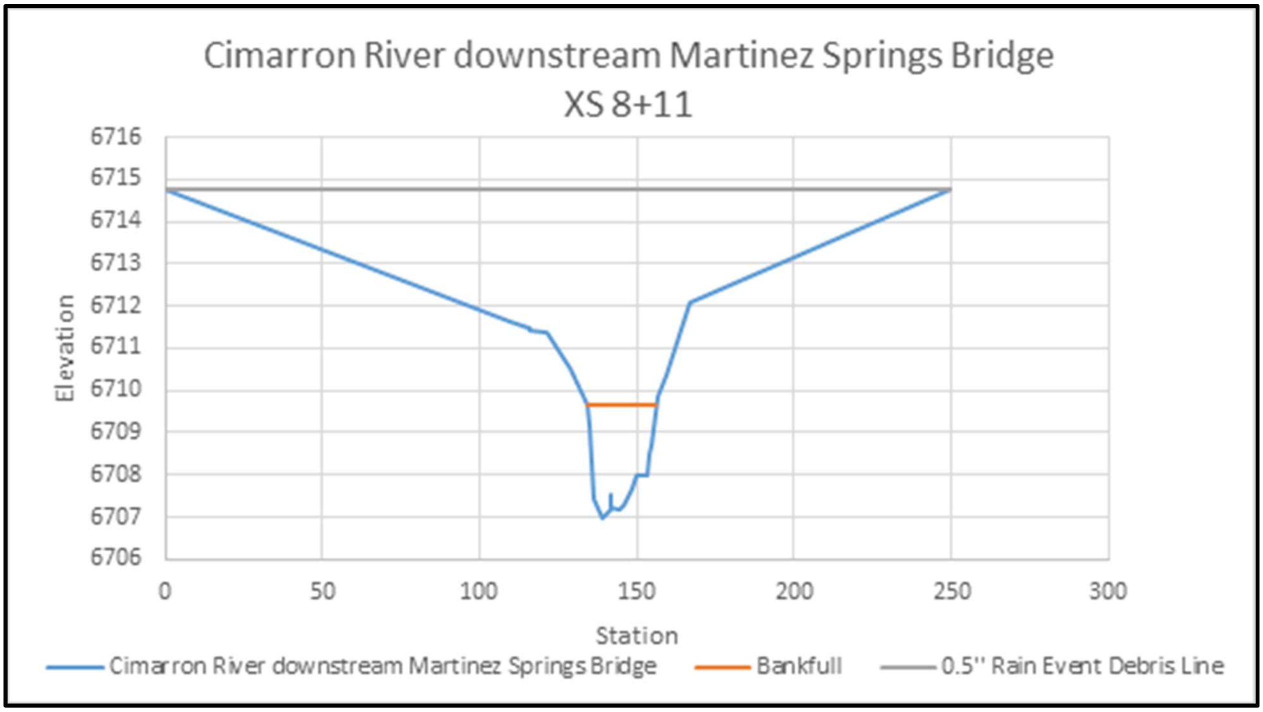

Figure 3.14. Shows a cross-section of the Cimarron River downstream of the Deer Lake alluvial fan and the burned Martinez Springs Bridge.

Figure 3.15. View looking south from the burned Martinez Springs bridge at the Cimarron River and the XS 8+11. Note the dark debris from the Cimarron River flows that spread across the floodplain during the July 12, 2018, event.

From the brief initial assessment of the watersheds in July 2018, the river assessment team has noticed a significant channel dimension enlargement on the steeper gradient supply reaches this is likely due to a greater than 400% increase in water yield post fire and confinement of the channels in steeper gradient reaches. The supply reaches within the watersheds that are smaller than 10 square miles will have a significant increase in both water and sediment yield due to the post-burn changes in the hydrology.

The reaches with drainage areas greater than 100 square miles within the watershed seem to have flatter slopes and wider floodplains to store excess sediments. These reaches still have a water yield of approximately 400% but the sediment being transported from the supply reaches to transport reaches is being deposited both within the channel and on the floodplain of these reaches. Sediment deposition may be thought of as a beneficial recovery process but excess aggradation can produce localized areas of sediment increased supply from horizontal instabilities, as well as problems to water delivery within the larger catchments and increased flooding. The photograph below shows an example of the flooding that is likely to continue to occur over the next 2 to 5 years until vegetation has established and the burned hillslopes have recovered (Figure 3.16).

Figure 3.16. Aerial view of Ute Park area showing a post-flood debris flow after 0.3 inch of rain on July 13, 2018.

On July 13, 2018, flood peaks were observed as a result of a 0.3-inch storm with a maximum hour intensity of less than 1.0 inch/hour and a maximum 30-minute intensity of 0.50 inch/30 minutes (USGS gage # 07207000). A storm of this magnitude is associated with less than a 1.1-year return interval. As a result of the fire, this relatively frequent rainstorm produced an infrequent and rarely observed flood event/debris flow at Ute Park. This drainage has an estimated pre-burn bankfull discharge of approximately 175 cubic feet per second (cfs) but experienced approximately 350 cfs from this 0.3-inch storm that generated a flood two times larger than the normal high flow for a relatively small rainfall total. In addition to the July 13 discharge there were six rainfall events in July 2018 that produced streamflows at the Cimarron River Gage that was greater than the pre-fire bankfull discharge of approximately165 cfs (Figure 3.17 below). As a result of the high sediment loading, deposition of sediment, and aggradation at the gage, the USGS has had to do significant maintenance to recalibrate the gage # 07207000.

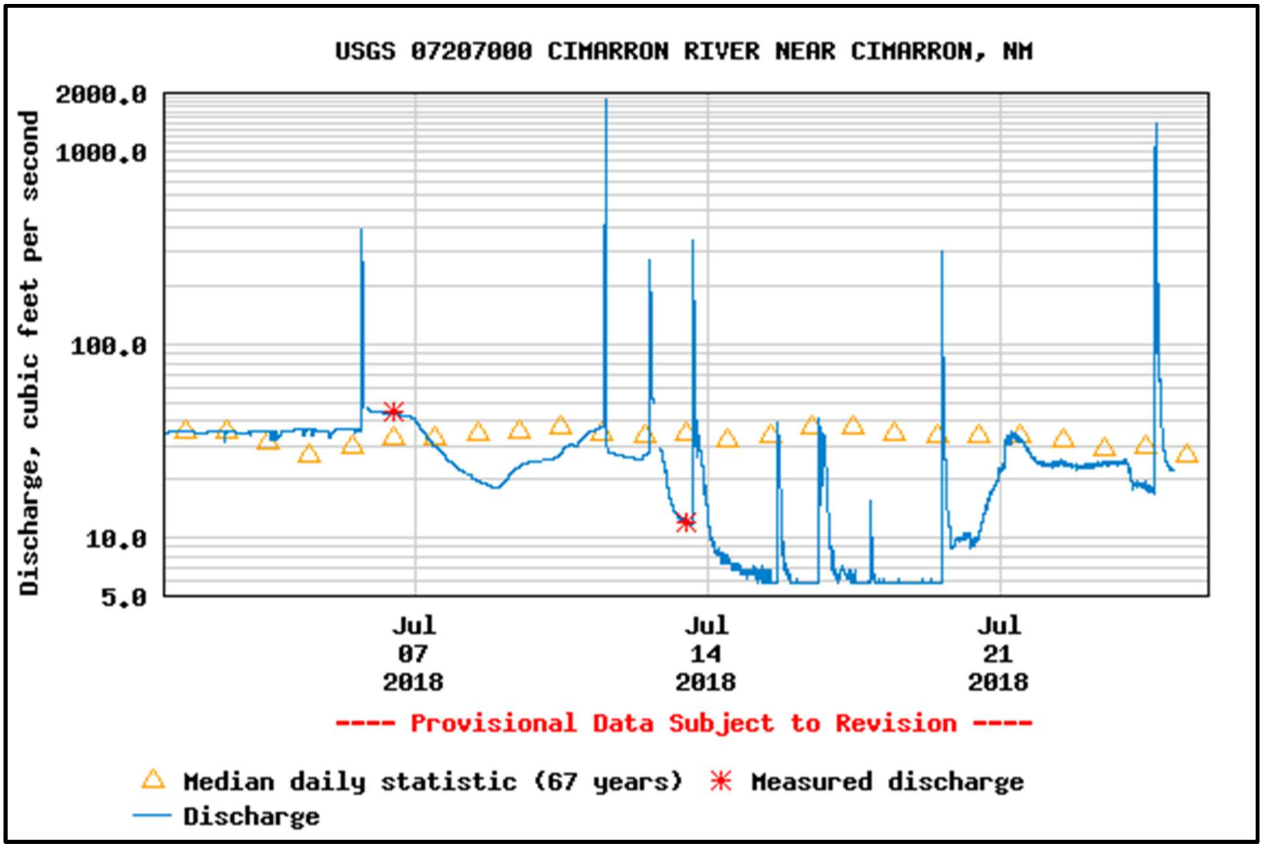

Figure 3.17. Instantaneous peak flow discharges that exceeded the pre-fire bankfull discharge six times during the month of July.

These July storms resulted in extensive damage to areas of Ute Park, to infrastructure and property, and damaged additional infrastructure owned by Raton, Springer, and Cimarron within the area. The predicted increases in water yield and higher magnitude, more frequent flood peaks will be long-term processes, but most pronounced in wetter years. Major changes in the post-fire hydrology drives the processes discussed later in this report and in future predictive-level reports. The increase in water yield is inversely proportional to the forest cover re-establishment, which may take decades for these watersheds especially in areas burned at a high severity.

We performed a reconnaissance-level analysis of the pre and post fire water yield utilizing the TR-55 method (NRCS 1996) for four of the critical watersheds. Input parameters for the water yield model are summarized below:

- Soil Type and Hydrologic Soil Group from SSURGO
- Rainfall Distribution Type II from NRCS: SCS Standard Rainfall Distributions.xlsx
- Ute Park Fire NOAA Precipitation Frequency Data
- Burn Intensity from RECOVER database

- Channel Length were measured from AutoCAD (Ute Gulch and Deer Lake Alluvial Fan), and StreamStats (Hummingbird and UT to Ute Park drainages).
- Runoff surface slope from StreamStats
- Channel slope from surveyed stream data in RiverMorph (Ute Gulch and Deer Lake Alluvial Fan)
- Channel dimensions from surveyed stream data in RiverMorph (Ute Gulch and Deer Lake Alluvial Fan)
- Hummingbird and UT channel dimensions were approximated based on StreamStats 2-year peak flow and compared with RiverMorph surveyed data
- Burn Severity CN interpreted from our field verified soil and vegetation data and https://forest.moscowfsl.wsu.edu/BAERTOOLS/ROADTRT/Peakflow/CN/supplement.html CN: verylow74, low83, moderate88, high95
- Manning's n from Chow (1959)

In summary, our reconnaissance-level analysis estimated a 600% to 3,300% increase in water yield that may occur during the first few years post fire (Table 3.2). Although these numbers seem high, this preliminary estimate qualifies the magnitude of the increase in water yield and is within the range of other studies of observed response. Data from other fires such as Rodeo-Chediski have shown post-fire streamflow can be up to 2,300 times the pre-fire flow conditions (Ffolliott et al. 2011).

Table 3.2. Estimated Percent Increase in Water Yield by Key Basins

Peak Flow by Return Period (cfs)									
		2-year				100-year			
Basin	**Drainage Area (sq. mi.)**	**Pre-Fire**	**Post-Fire**	**ΔQ**	**% change**	**Pre-Fire**	**Post-Fire**	**ΔQ**	**% change**
Ute Gulch	10.1	205	1,531	1326	747	1,908	4,977	3,069	261
Deer Lake Alluvial Fan	3.0	179	1,150	971	642	1,356	3,236	1,880	239
Hummingbird	3.1	27	898	871	3,326	655	2,859	2,204	436
UT to Ute Park	1.2	11	167	156	1,518	161	1,014	853	630

Hillslope Processes

Significantly large sediment yields from post-fire floods can be expected from the Ute Park burn because of rain events ranging from 0.5 to 1.5 inch/hour. Due to the severe microclimate extremes, droughty soils and low precipitation, a slow natural hydrologic recovery of these sites is anticipated.

Overall, post-fire erosion rates are highly dependent on the amount of surface cover on the forest floor (Figure 3.18 and Figure 3.19). The importance of surface cover is demonstrated by the fact that mulching has been the most successful post-fire erosion treatment in other burn areas in both Colorado and New Mexico, as this immediately provided a protective ground cover. Treatments that disturb the soil surface, such as scarification, may increase the hillslope erosion rate relative to untreated areas in the short term but could increase the rate of revegetation.

Figure 3.18. An example of the high burn severity forest floor.

Figure 3.19. Aerial view of the hillslope sediment producing multiple debris flow paths transporting across the burn forest floor to the Ute Gulch channel. This aerial photograph was taken after the first significant precipitation event to occur post-fire.

A large flow-related measured sediment yield for the control (no surface ground cover treatment) between 2003 and 2005 generated 8.8 tons/acre from a 1.7-inch/hour storm, resulting in 650 csm of runoff within the Hayman burn study plots (Robichaud et al. 2006). In 2007, a 4.3-inch/hr storm for 10 minutes generated a high peak flow of 1,064 csm (Robichaud et al 2008). The sediment yield from this storm, however, was lower due to increased ground cover, yielding less than 1.5 tons/acre, much less than the 8.8–10 tons/acre immediately following the fire associated with a much lower magnitude storm. These research data reflect the surface erosion and hillslope process recovery of ground cover density 5 years following the fire (Robichaud et al. 2008). Figure 3.20 below is adopted from the Robichaud study.

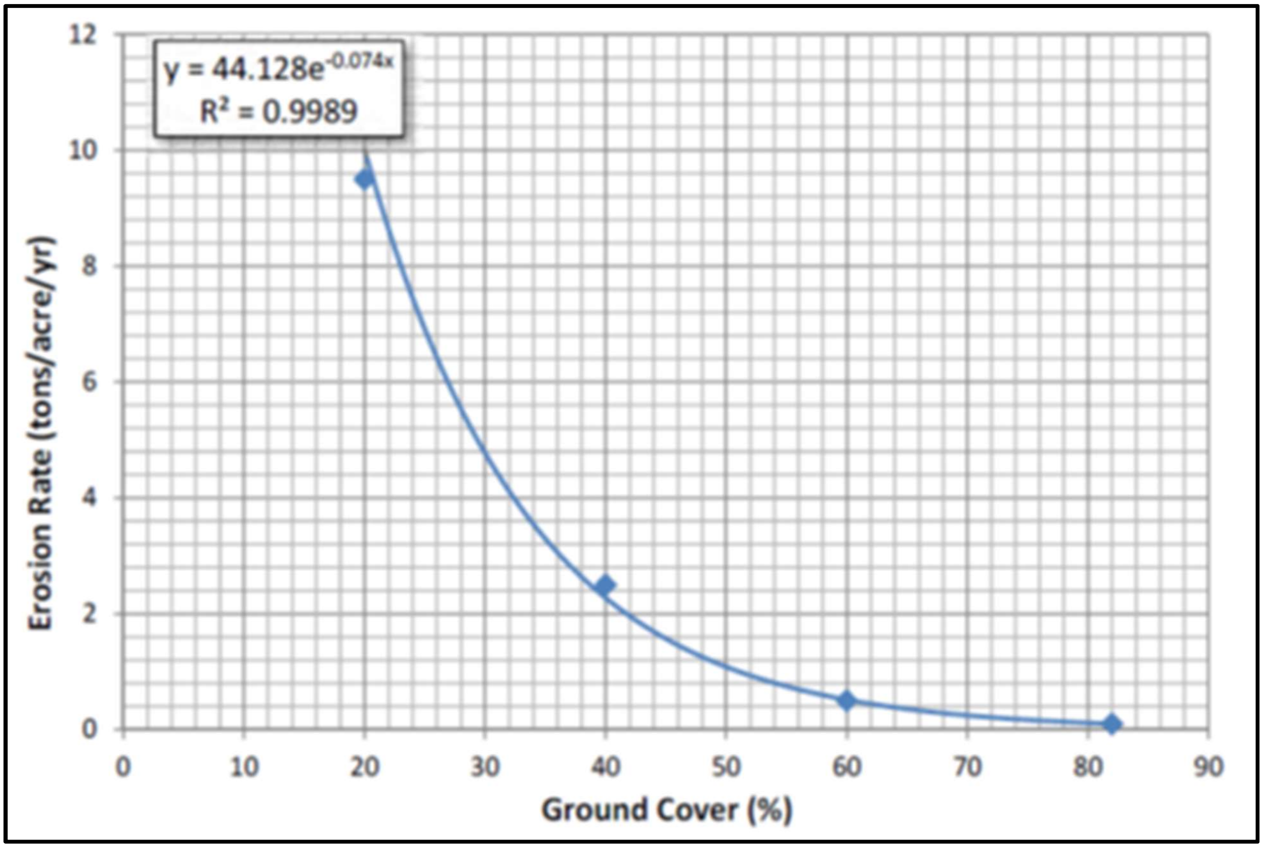

Figure 3.20. Surface Erosion sediment yields by ground cover density 20-40% slopes, as derived by Wildland Hydrology from Robichaud et al. (2009).

Robichaud et al. (2009) showed “no significant” differences in erosion rate between 20% and 40% slopes. Previous studies have shown that slopes greater than 20% are critical areas that will produce the most amount of hillslope sediment.

The “nonwettable” or hydrophobic soil condition that reduces infiltration is reduced after the first three years (Robichaud et al. 2009). It was observed during the site assessment that hydrophobic soil conditions were present in all burn severities, however it was discontinuous and not widespread throughout the Ute Park Fire due to the low residence time of fire on the surface. As a result, the hydrologic parameters were manipulated in terms of curve number used to help estimate water yield and erosion changes as result of the fire.

During previous post fire assessments, a delivery ratio has been applied to the erosion rate using the Sediment Delivery Index (U.S. Environmental Protection Agency 1980). The Sediment Delivery Index estimates the portion of surface erosion that is delivered to the stream systems. Post-fire sediment yields can be up to three orders of magnitude greater than sediment yields in unburned forests (Robichaud and Wagenbrenner 2009).

For this reconnaissance-level study SWCA utilized the Erosion Risk Management Tool (ERMiT) model to determine the likelihood of exceedance for rain event erosion rates. The input variables are climate, soil texture, soil rock content, vegetation type, hillslope slope and horizontal length, and soil burn severity.

Eighteen scenarios were chosen based on the most prevalent soil type, burn severity, and hillslope characteristics. All vegetation type was modeled as forest (Figure 3.21). Soil Type was based on the Unified Soil Classification.

Figure 3.21. Typical structure of the forested vegetation that was common before the fire.

System, rock content, and some slope information is obtained from soil survey. Hillslope characteristics are obtained from GIS.

For each scenario, the pre-fire sediment yield and post-fire sediment yield at 30% precipitation exceedance probability is obtained. For example, in scenario 1, for pre-fire conditions, there is a 30% chance that the modeled hillslope will deliver 0.01 ton/acre. In the same scenario at post-fire and high burn severity, the same hillslope will have a 30% chance of delivering 3.41 tons/acre of sediment during the first year following the fire. However, as vegetation becomes established the model shows sediment delivery recovers to pre-fire conditions after 3 years. In scenarios with high burn severity, slopes equal to or greater than 1000 linear feet in length, with gravelly and sandy loam soils, do not show recovery to pre-fire conditions for 5 years.

The erosion potential for the entire burned site ranged from less than 1 ton/acre to 10.08 tons/acre following the first year after the fire. Seeding and mulch treatment scenarios were modeled for the first 3 years following the fire. The model shows that applying 0.5 ton/acre of mulch can significantly reduce the sediment yield following years 1 and 2; however, mulching treatments become less effective in subsequent years. The model shows seeding treatments following year 2 are almost as effective as mulching. Table 3.3 below summarizes results from the ERMiT model.

Channel Processes

Large amounts of sediment are still generated years after large fires (MacDonald 2009); 70% to 90% of the total sediment in the watershed has been attributed to channel source sediment from increased runoff and unstable stream channels. This increase in sediment can be attributed to extreme storms where there is still sufficient runoff to cause further channel incision and streambank erosion (MacDonald 2009).

There exists a high likelihood of debris flows/debris avalanche processes due to flood-related stormflow response and unstable channels in highly erodible material. The prediction of such processes is extremely difficult. On-site mitigation for such processes is nearly impossible; thus channel reconnection and functional use of alluvial fans become critical geomorphic components that should be considered for the restoration design phase where natural recovery processes could not be allowed to develop in-time without negative consequences.

The function of alluvial fans is to naturally store sediment directly below high sediment supply and high transport stream types, such as A3a+, A4a+, A5a+, A3–A5, F3–F5, and G3–G5 stream types.

Table 3.3. Reconnaissance-level ERMiT Input and Output for 3 years following the Ute Park Fire at a 30% Probability Precipitation Event

Scenarios	Soil Burn Severity	Vegetation Type	Soil Texture	Rock Content %	Hillslope Horizontal Length (feet)	Slope Middle %	Sediment Delivery (tons/acre) Pre-Fire – Background Conditions	Sediment Delivery (tons/acre) Post-Fire (untreated) – First Year	Sediment Delivery (tons/acre) Post-Fire (mulching 0.5 ton/acre) – First Year	Sediment Delivery (tons/acre) Post-Fire (seeding – First Year	Sediment Delivery (tons/acre) Post-Fire (untreated) – Second Year	Sediment Delivery (tons/acre) Post-Fire (untreated) – Third Year
1	High	Forest	silt loam	5	700	20	0.01	3.41	0	3.41	1.49	0.01
2	Moderate	Forest	silt loam	5	700	20	0.01	0.89	0	0.89	0.39	0
3	Low	Forest	silt loam	5	700	20	0.01	0.36	0	0.36	0.12	0
4	High	Forest	gravelly loam	20	700	30	0.01	7.56	1.13	7.26	5.32	0.83
5	Moderate	Forest	gravelly loam	20	700	30	0.01	4.23	0.61	4.23	3.18	0.17
6	Low	Forest	gravelly loam	20	700	30	0.01	2.03	0.16	2.03	1.23	0.17
7	High	Forest	cobbly loam	30	400	50	0.02	6.93	1.65	6.93	5.2	1.45
8	Moderate	Forest	cobbly loam	30	400	50	0.02	4.58	1.23	4.58	3.97	0.39
9	Low	Forest	cobbly loam	30	400	50	0.02	2.71	0.36	2.71	2.39	0.39
10	High	Forest	gravelly sandy loam	20	1000	40	0.04	8.58	0.98	8.58	6.64	0.79
11	Moderate	Forest	gravelly sandy loam	20	1000	40	0.04	4.22	0.74	4.22	1.95	0.13
12	Low	Forest	gravelly sandy loam	20	1000	40	0.04	1.17	0.09	1.17	1.08	0.13
13	High	Forest	stony sandy loam	35	900	35	0.02	10.08	0.23	10.08	6.15	0.31
14	Moderate	Forest	stony sandy loam	35	900	35	0.02	2.65	0.17	2.65	1.78	0
15	Low	Forest	stony sandy loam	35	900	35	0.02	1.43	0	1.43	1.2	0
16	High	Forest	very stony clay loam	40	700	45	0.02	8.03	2.73	8.03	6.51	2.52
17	Moderate	Forest	very stony clay loam	40	700	45	0.02	6.34	2.14	6.34	5.39	1.04
18	Low	Forest	very stony clay loam	40	700	45	0.02	4.05	1.05	4.05	3.36	1.04

The stable stream types for actively building, alluvial fans are the braided, D3–D5 stream types. The braided channel types disperse flow by convergence/divergence bed feature processes and induce sediment deposition over the width and length of the fan (Figure 3.22 and Figure 3.23).

Figure 3.22. Photograph looking up at the Deer Lake Mesa gully and alluvial fan.

Figure 3.23. Photograph looking west across the delta of the Deer Lake Mesa alluvial fan.

Stream type succession is used to interpret and predict the potential stable morphological state. Sixteen stream succession scenarios and stream type shifts toward stable end points for each scenario are presented below (Figure 3.24). These scenarios represent various sequences from actual rivers and are used to assist in predicting a river's behavior based on documentation of similar response from similar types for imposed conditions. Note that more scenarios exist than the 16 depicted. It is important to select the appropriate scenario and current stage of stream succession to assist in selecting the stable, end-point stream type for restoration. Scenario #3, associated with the C4 to D4 to G4 to F4 to C4 stream type succession, is occurring in Ute Gulch.

In several scenarios, a C4 stream type is shifted to a G4 stream type (e.g., Scenarios #1, #4, #8, #9 and #12). The C4 to G4 stream type shift is due to either widening or an avulsion that then headcuts back into the previous, over-wide C4 stream type creating a G4 stream type. Another process leading to a C4 to G4 stream type conversion is a local lowering of base level where the bed elevation of the receiving stream is lowered. This process is termed tributary rejuvenation or over-steepening headward. Another cause can be the presence of debris jams or beaver dams; the aggradation caused by high sediment supply raises the local base level above the dam, and then over-steepens the slope, causing lateral migration around the channel blockage, resulting in a channel headcut or G4 stream type. The sediment consequence from channel incision when G4 channels are created is accelerated streambed and streambank erosion rates. In certain situations, the restoration direction is to convert the G4 stream type to a B4 stream type. This is appropriate where the meander width ratios (channel belt width divided by bankfull width that represents the degree of confinement) and entrenchment ratios (width of the flood-prone area divided by bankfull width that represents the degree of entrenchment) are both less than 3.0.

Stream successional scenarios #13 and #16 are potentially appropriate for application on active alluvial fans (Valley Type IIIa). Previously, headcut channels (fan-head trench channels) have been incised in the fan deposit causing loss of fan function. Subsequent flows and sediment are rapidly routed downstream with resultant streambed and streambank erosion. The modification to scenarios #13 and #16 would be to raise the level of the eventual braided, D channel back up to the original fan surface to restore the fan function by dispersing flow energy and storing sediment. Overall, the use of stream succession in design is dependent on the existing stream type and the stable potential type based on a valley type that matches the boundary conditions and the controlling variables.

Water Quality Issues

Impacts to water quality as a result of a wildfire can produce significant changes that have the ability to impact drinking water supplies, fish and other aquatic organisms, and wastewater treatment systems (septic tanks). Post-fire delivery of ash and sediment is the greatest concern for surface water health post-fire.

Large post-fire sediment fluxes impact drinking water systems in two ways: 1) reservoirs, infiltration basins and treatment works may be filled with sediment, and 2) high sediment load is likely to increase pre-treatment processing needs and costs for suspended sediment removal. These impacts to treatment works and reservoirs can be felt as far as 100 miles away (Meixner 2004). Drinking water treatment processes operate more effectively when source-water quality is constant (USGS 2012). Post fire hydrology differs from normal hydrologic conditions, especially in the Southwest, because burned watersheds are prone to flash floods following monsoonal rainstorms that transport substantial amounts of sediment to downstream water bodies in pulses. This has significant implications for water treatment processes.

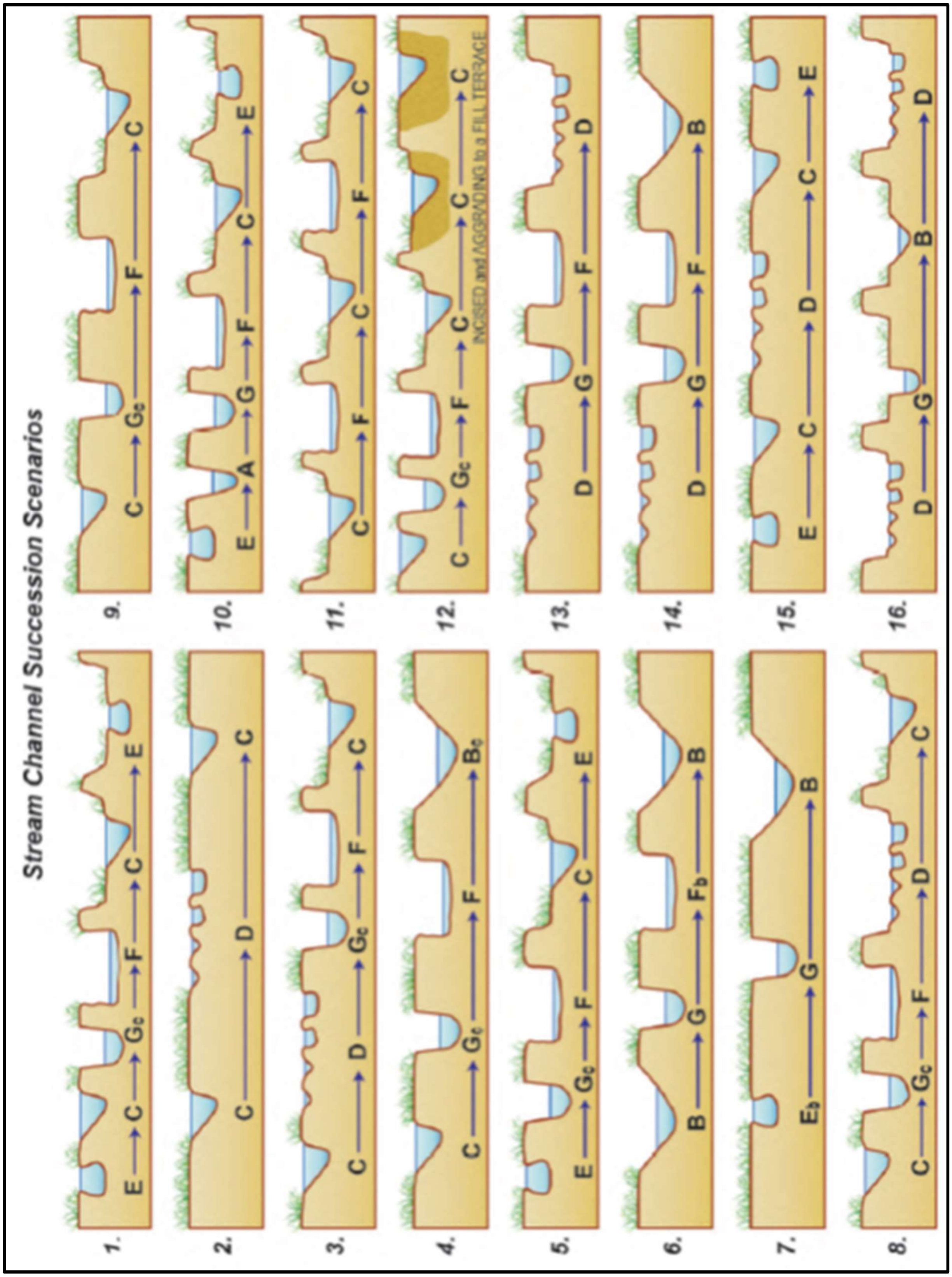

Figure 3.24. Various stream succession scenarios and corresponding stages of adjustment (Rosgen 2006, 2009).

One of the most significant effects of wildfire on water quality is the observed impact to chemical composition (Stevens 2013). High alkalinity runoff from burned areas can increase surface water pH temporarily, and ash input coupled with sediment transport can contribute to increased nutrient levels, particularly phosphorous and nitrogen, as well as algal blooms, with concentrations returning to pre-fire conditions within several days to several months. Human health could be adversely affected from either short or long-term exposure to contaminants in the water, and sediment may cloud water or cause it to taste or smell earthy or smoky. These impacts are cumulative as a result of pollutants mobilized by the fire, chemicals used to fight the fire, and the post-fire response of the landscape.

In some studies, the primary drinking-water standards for dissolved metals were not exceeded in post-fire flood events, but secondary drinking-water standards (which are related to aesthetic considerations, such as taste, color, and odor) for aluminum, iron, and manganese were exceeded downstream of the burned area (USGS 2012). In the first rain events post-fire, studies have shown that dissolved organic carbon (DOC) increase significantly from baseflow levels, often exceeding treatment thresholds (USGS 2012). Similarly nitrate concentrations in streams during the postfire period, have been found at concentrations as much as 10 times the federal drinking water standard (Meixner 2004). DOC and other organic compounds encourage growth of microorganisms that may produce taste and odor impacts (Volk et al. 2005); these compounds may be removed or decreased by oxidation early in the treatment process (Satterfield 2006a).

The potential abundance of fine sediment, organic matter, manganese, and taste and odor compounds may decrease the efficiency of treatment processes and the quality of finished drinking water (Stevens 2013). Fine suspended sediment (measured in terms of turbidity) can make drinking-water disinfection more difficult and facilitates the growth of bacteria in the distribution system (Landsberg and Tiedemann 2000). Removal of excess suspended sediment (including particulate organics) may require additional coagulation chemicals and settling time and may slow plant production (Satterfield 2006b).

These impacts to water quality have been found to last more than 5 years in similar burned watersheds (Rhoades et al. 2011). Monitoring of source water downstream of burned watersheds may allow water managers to minimize objectionable effects, by temporarily diverting some water or changing source water. Although enhanced treatment can be successful in mitigating postfire runoff problems, increased cost may result from increased use of chemicals and waste disposal (Stevens 2013). The rapidly changing quality of postfire runoff from storms necessitates the adjustment of the treatment process to changes in raw water quality (Satterfield 1998) that complicates process optimization (Cottingham 2005).

Livestock water may become contaminated during post-fire runoff. Ash may contain trace levels of lead, antimony, arsenic, copper, mercury or zinc which can cause sickness in some livestock, depending on concentrations.

Irrigation water quality may deteriorate over time due to runoff post-fire. Water may have an increase in pH, total salt content, ash, and sediment concentration. A pH greater than 8.5 is considered high for irrigation water. High levels of ash and sediment may clog filtration systems of sprinklers and drip systems, restrict head gates and diversion structures, and settle out in canals and ditches reducing flow.

Engineering and Hydrology Recommended Treatment Opportunities

Based on our reconnaissance-level analysis we developed a matrix to help describe general treatments and provide a rough cost estimate for those treatments. Table 1.5 above (see page 17) provides a list of recommended treatment opportunities that will make the greatest impact to reduce damage caused from an increase in water and sediment, replace already-impacted infrastructure, and mitigate for the anticipated future impacts to infrastructure and clean water beneficial uses.

Figure 3.25 below shows the approximate locations for the reconnaissance-level treatment opportunities that are described in Table 1.5.

Estimated Costs

Total estimated construction costs for fully designed structures capable of storing the maximum sediment possible and replacing all necessary infrastructure could range up to approximately $18,500,000, and design and permitting fees could be estimated around approximately $2,250,000. This construction estimate would be refined during the Predictive Level Assessment (PLA) phase of the project.

It is estimated that the preliminary concept designs would remove 183,000 tons of sediment from being transported in the watershed at a cost of $20,750,000 or approximately $113/TN.

It is important to note that this project is scalable, and cost can be significantly reduced based on a future predictive-level assessment, master planning process, and the use of a Multi-Criteria Analysis tool for prioritizing available funds. In addition to the matrix in Table 1.5 above, we have prepared a more detailed description of selected reconnaissance-level treatments.

UTE GULCH IN-LINE BASIN

Location: Located in Ute Gulch, approximately 3,880 feet upstream of the confluence with Cimarroncito Creek (Figure 3.26). Approximate coordinates are N: 1998939.9 E: 332449.5.

Problem Statement: Ute Gulch is located in a high burn severity area with steep slopes, numerous gullies, and highly erodible soils. Ute Gulch is an intermittent tributary to Cimarroncito Creek. The Webster Reservoir diversion is located about 3,200 feet downstream of the confluence with Cimarroncito and Ute Gulch; or approximately 7,000 feet downstream of the proposed treatment area.

Treatment Recommendation: Construct an in-line sediment basin to trap and store sediments and reduce downstream sediment loading into Cimarroncito Creek. Stabilize the existing channel designed with a cross sectional area to anticipated for the predicted Q2-yr post fire. Utilize on-site materials and natural channel design techniques to withstand the Q100-yr post-fire flow event. Install grade control structures in the channel that will backfill with post-fire sediments and raise the bed elevation and spread flows more frequently across the floodplain. Construct a sediment trap at the downstream extents to capture excess hillslope sediments. Install floodplain roughness features to trap sediments.

Load Reduction: Approximately 25,000–40,000 tons.

Maintenance: Minimal. Project is anticipated to fill in with sediment between 2 and 10 years. Channel structures will be placed to train flows and function in dynamic equilibrium with the changes in flow and sediment. After the life of the project (2–5 years) revegetation work is anticipated to restore the project area.

Cost Estimate: $350,000–$500,000

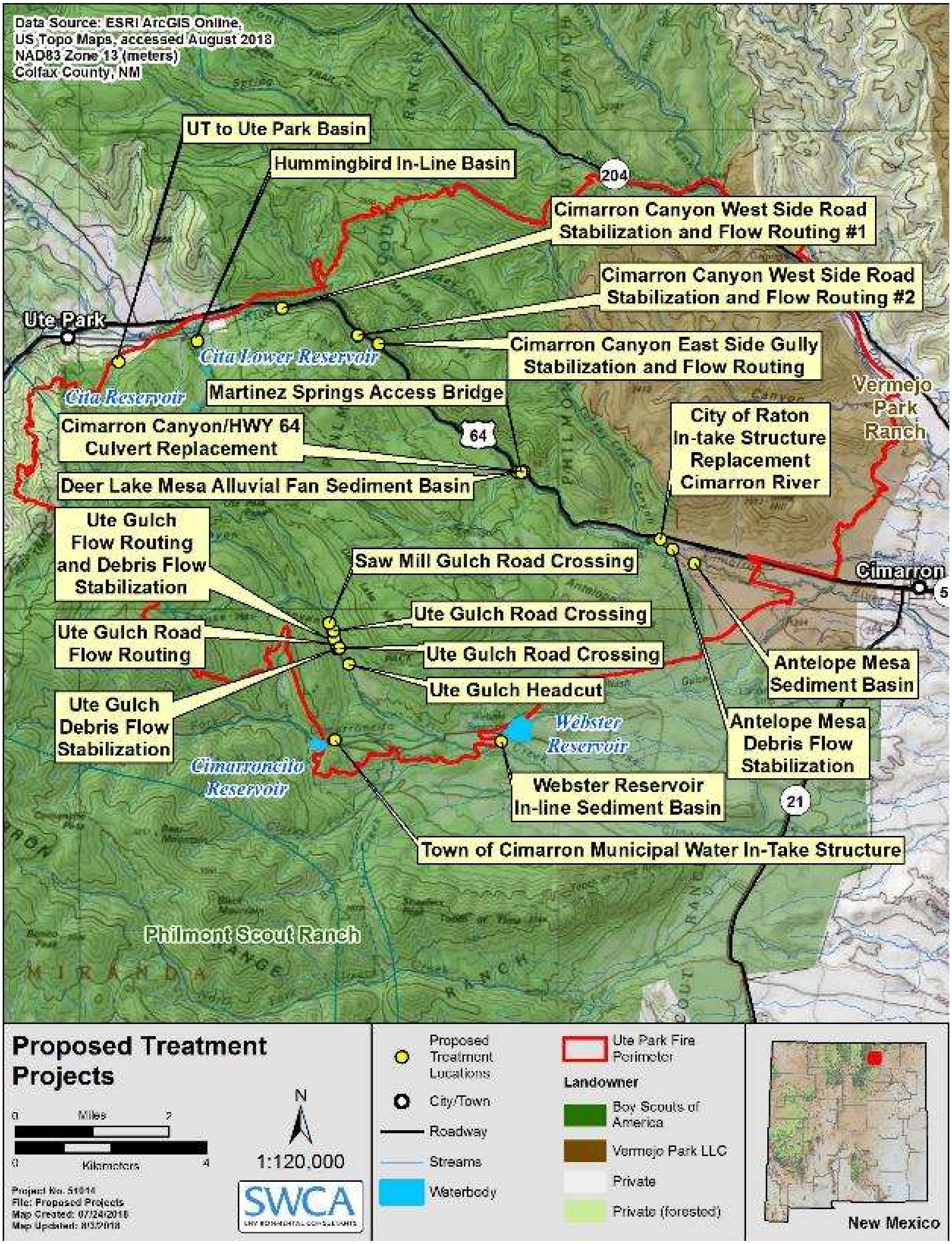

Figure 3.25. Approximate locations for the reconnaissance-level treatment opportunities proposed.

Figure 3.26. Ute Gulch intermittent channel near the recommended in-line sediment basin location.

DEER LAKE MESA ALLUVIAL FAN SEDIMENT BASIN

Location: The Deer Lake Mesa alluvial fan is an ephemeral tributary to the Cimarron River. It is located in Cimarron Canyon along U.S. Highway 64 on the west side of the valley (Figure 3.27). Approximate coordinates are N: 2013895.7 E: 342600.1.

Problem Statement: Deer Lake Mesa experienced high burn severity. A large ephemeral gully has built up an alluvial fan at the valley floor. The alluvial fan is still active. This is a relatively large gully with a very high transport capacity which flow through a tight valley confined by bedrock and steep colluvial slopes. The Deer Lake Mesa has potential to produce a significant amount of sediment with mass debris flows, RLA estimated a 642% increase in water yield and 6-10 tons/acre of sediment increase from the 2-yr event (Refer to ErMit and TR-55 tables above) that could potentially deposit significant debris in the Cimarron River causing a temporary dam effect forcing the Cimarron River to flow against the left bank, leading to lateral migration and possible capture of U.S. Highway 64, leading to significant damage to the highway.

Treatment Recommendation:

Construct a sediment basin at the toe of the alluvial fan to trap and store sediments. Install grade control structures that will fill with upslope sediments within the mainstem of the gully, and promote more frequent inundation across the delta to provide additional sediment storage within the existing alluvial fan. Dredge a sediment basin at the toe to trap sediments delivered from the high severity burn area on Deer Lake Mesa. Figure 3.28 and Figure 3.29 below show an example adopted from a previous design study.

Figure 3.27. View looking west towards historic alluvial fan delta and the new delta forming.

SWCA would recommend a potential Sediment Basin and Alluvial Fan.

Load Reduction: 50,000–60,000 tons

Maintenance: Minimal. Project is anticipated to fill in with sediment between 2 and 5 years. Project storage capacity should be inspected after significant flow events, and periodically throughout the life of the project. A significant large event within that time period may require dredging to restore temporary capacity. After the life of the project (2–5 years) revegetation work is anticipated to restore the project area.

Cost Estimate: $500,000

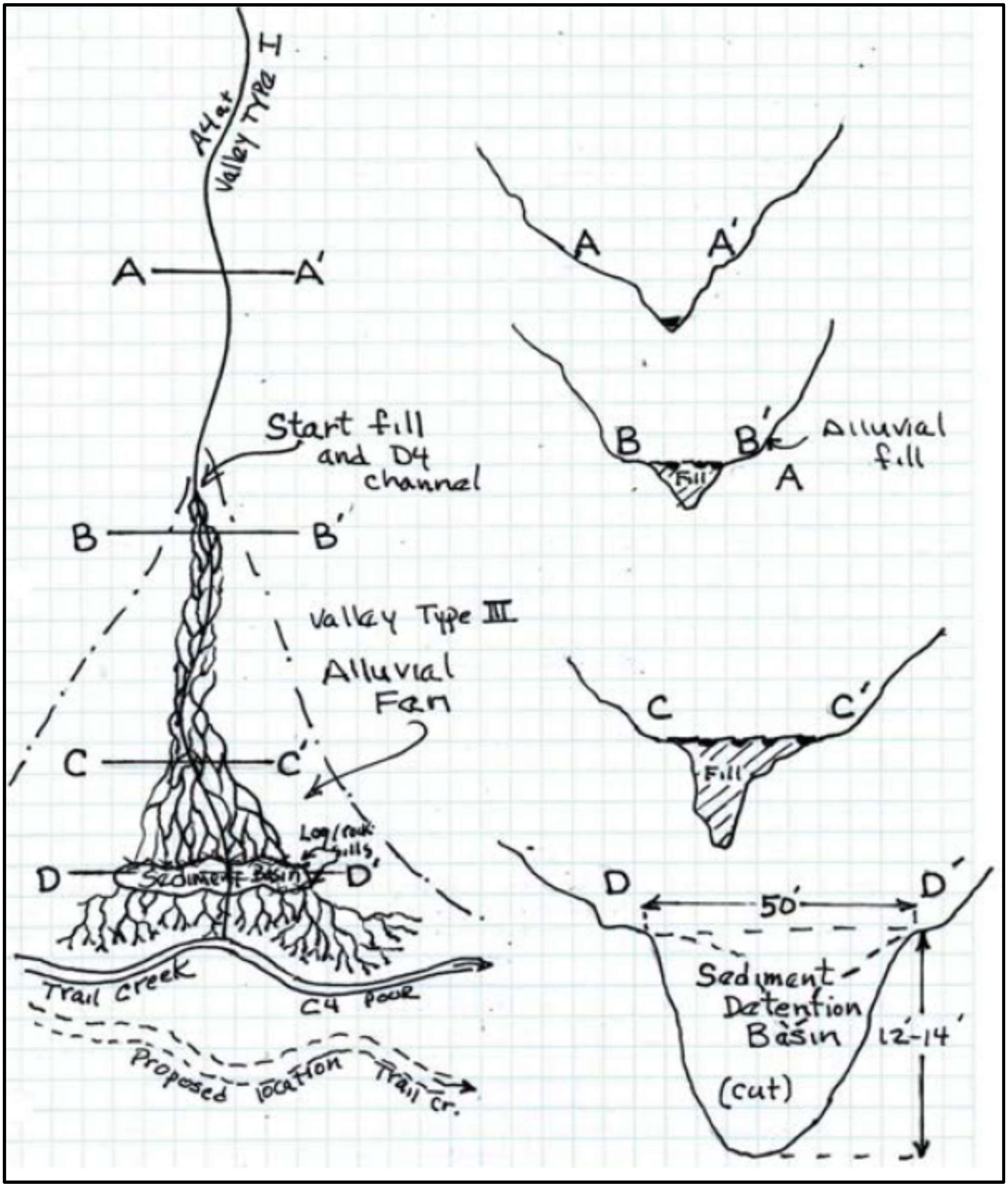

Figure 3.28. Example preliminary design of sediment basin and alluvial fan (Source: Wildland Hydrology 2011).

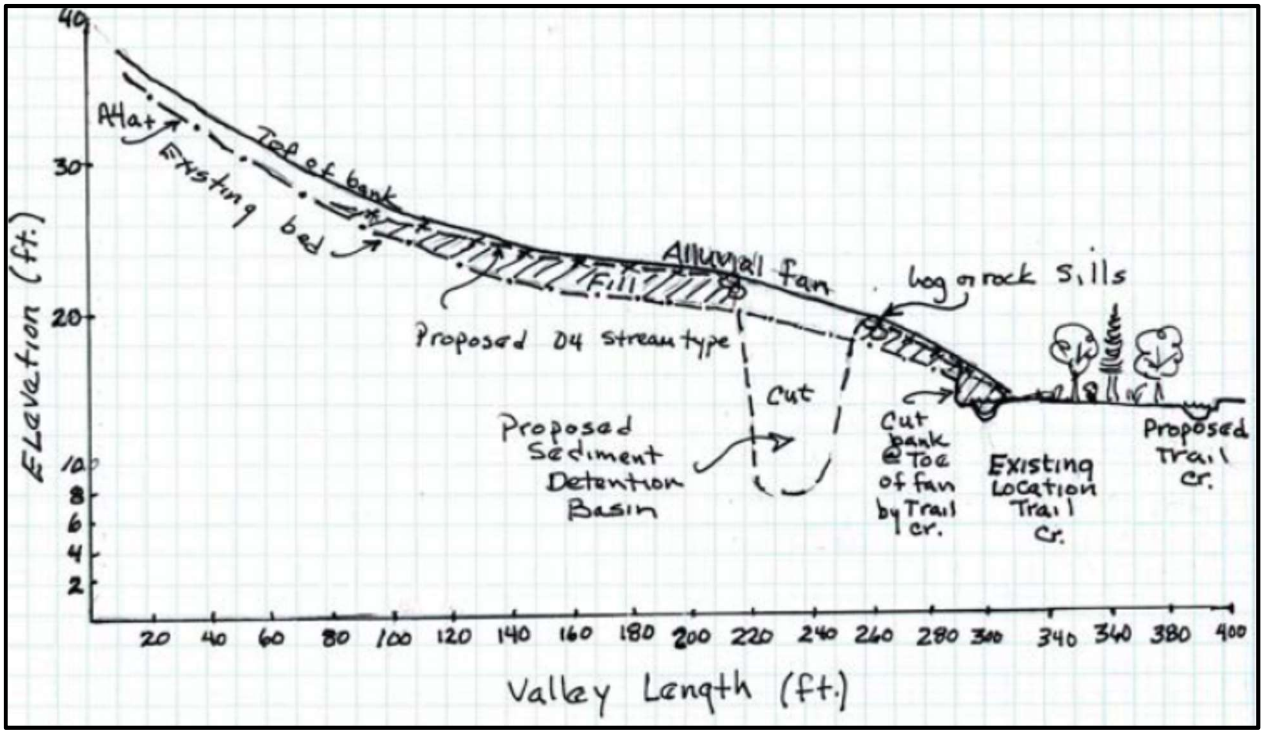

Figure 3.29. Example preliminary design of sediment basin and alluvial fan (Source: Wildland Hydrology 2011).

VILLAGE OF CIMARRON SECONDARY WATER IN-TAKE STRUCTURE

Location: Located in the Cimarron River downstream of the U.S. Highway 64 Canyon mouth approximately 850 feet downstream of the USGS gage station (Figure 3.30). Approximate coordinates are N: 2009221 E: 352385.

Problem Statement: The existing structure is a channel-wide concrete sill. The structure is positioned where the highest sediment deposition will occur. The structure is not functional and will likely not be functional without active measures. The channel has been channelized and encroached on the left bank by a berm (buried intake pipe).

Treatment Recommendation: Remove and replace concrete sill with boulder grade control structures, repositioned to train the thalweg and reduce backwater sedimentation. Reconfigure the channel to reduce encroachments, restore channel dimensions and planform to promote bankfull/floodplain sediment storage, and stabilize the channel to reduce in-channel erosion due to an increase in water yield. Reconfigure the intake structure to be positioned at a 45-degree angle downstream facing (vs. existing upstream facing), to significantly reduce sedimentation. Project could be combined with replacement of the USGS gage station control structure, and debris basin(s) from the high burn severity area at Antelope Mesa.

Load Reduction: Not applicable

Maintenance: Existing maintenance will be significantly reduced by repositioning the intake structure and reconfiguring the channel. Regular maintenance to adjust flow to proportion water, remove animal/beaver activity, vegetation encroachments, and inspect for damaged caused by weather, vandalism, or other unforeseen events.

Cost Estimate: Approximately $500,000 to $1 million

Figure 3.30. View of existing City of Cimarron secondary intake structure.

TOWN OF CIMARRON MUNICIPAL WATER IN-TAKE STRUCTURE

Location: Located in the Cimarroncito Creek downstream of Cimarroncito Reservoir (Figure 3.31). Approximate coordinates are N: 1995579.4 E: 329917.7

Problem Statement: The intake structure reservoir pool is immediately downslope of a high burn severity steep hillslope. Ash and debris were filling the pool during the time of survey. This is the primary source of drinking water for the town of Cimarron.

Treatment Recommendation: Replace structure with a larger, and higher crest elevation, designed with an intake pump raised off the bottom of the pool, with a strainer/filter system.

Load Reduction: Not applicable

Maintenance: Regular maintenance to adjust flow to proportion water, remove animal/beaver activity, vegetation encroachments, and inspect for damaged caused by weather, vandalism, or other unforeseen events. Pump maintenance may require regular cleaning of strainer/filter system during the first few years until vegetation has recovered on the adjacent hillslope.

Cost Estimate: Approximately $200,000

Figure 3.31. View of existing Town of Cimarron intake structure. Notice the pool is black and filled with ash/debris from the adjacent hillslope that received high severity burn.

Hummingbird In-Line Basin

Location: An unnamed intermittent stream, titled Hummingbird Lane for the purposes of this study, is a tributary to the Cimarron River and generally flows from south to north through the east end of the community of Ute Park (Figure 3.32). Geomorphic RLA field surveys were not conducted in this drainage.

Problem Statement:

The upper watershed of Hummingbird Lane is within the high burn severity area, and the middle to lower elevations are within the moderate burn severity watersheds. The upper watershed is predominantly Fuera-Dargol-Vamer soils (NRCS Websoil Survey, accessed July 2018), a deep-profile cobbly loam soil with a very high runoff rating. The intermittent channel flows through a residential area in Ute Park and has the potential to impact residential homes, roads, and clean water beneficial uses. The intermittent channel has the potential to produce significant debris flow events immediately following the fire, and flood events within the first 5 years following the fire. High-flow events have potential to capture the road, most likely at the downstream in-channel pond location.

Treatment Recommendation: There are two in-line ponds that may be enlarged to serve as in-line sediment basins with landowner cooperation. One is located approximately 1,000 feet upstream of the confluence with the Cimarron River, and the other is 1.1 miles upstream of the confluence. An alternative would be to construct an in-line sediment basin approximately 1,700 feet upstream of the confluence with the Cimarron River in an open meadow.

Load Reduction: Approximately 25,000 tons.

Maintenance: Enlargement of the existing ponds would require periodic dredging to maintain the pool and maintain existing water right beneficial uses. Dredging is likely necessary immediately following significant debris flow events, and in the fall and spring to restore capacity for at least the first 2 years, with potential annual dredging for the first 5 years. Seasonal inspections should be done in the spring and fall to ensure sediment and water storage capacity, with periodic inspections occurring after significant precipitation events. An alternative in-line sediment basin would be filled within 2 to 10 years and would not require regular maintenance, however would require revegetation after the life of the project.

Cost Estimate: Approximately $500,000 to $1 million

Figure 3.32. View of an unnamed intermittent stream, titled Hummingbird Lane for the purposes of this study.

UT to Ute Park

Location: An unnamed intermittent stream, titled UT to Ute Park for the purposes of this study, is a tributary to the Cimarron River and generally flows from south to north through the community of Ute Park. Geomorphic RLA field surveys were not conducted in this drainage.

Problem Statement: The community of Ute Park has already experienced significant flooding laden with ash and debris during the relatively small 0.3-inch storm that occurred on July 13, 2018. Flooding and associated sediment have potential to impact multiple dwelling, roads, other infrastructure, and clean water beneficial uses. The watershed is predominantly Abreu-Cypher soils, which is a gravelly loam to clay loam with bedrock at 43–47 inches and a high runoff classification. This area also has been shown to be susceptible to landslides, with two previous deep slide deposits being located above Ute Park as seen in the landslide susceptibility map below (Figure 3.33).

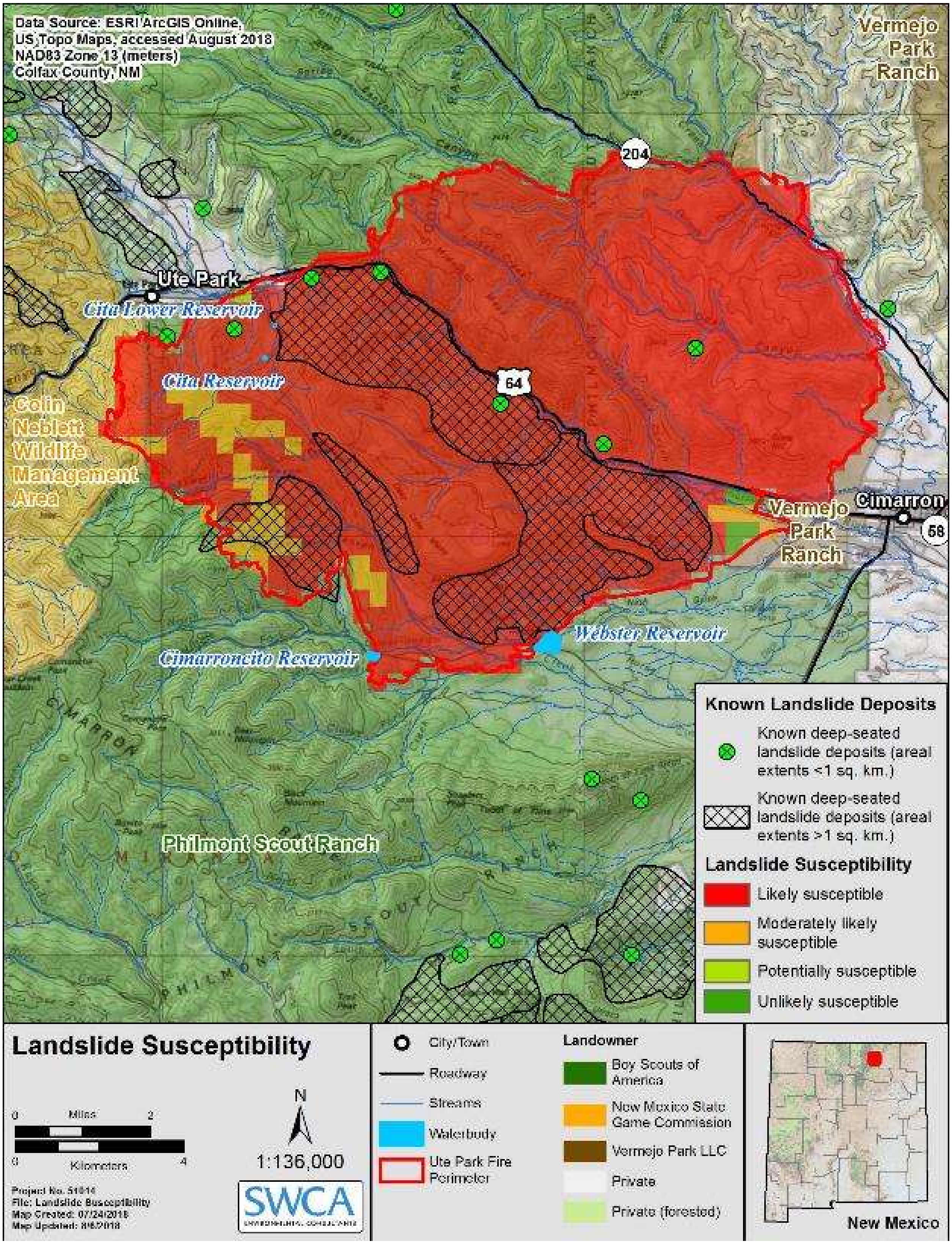

Figure 3.33. Landslide susceptibility within the Ute Park Fire perimeter (developed by Cikoski and Koning 2017).

Treatment Recommendation: The intermittent tributary appears to be relatively confined until the community of Ute Park. A series of grade control structures and terraces would intercept the runoff and reduce flooding velocities within the confined valley. A series of small debris basins would retain sediment and reduce water quality impacts. Installing berms and routing flow in the community of Ute Park would protect residential homes. Install culvert(s) to pass the flows at Magpie and Eagle Lane roads.

Load Reduction: Approximately 40,000 tons.

Maintenance: Revegetation, and periodic maintenance of culverts and routed flow.

Cost Estimate: Approximately $500,000 to $1 million

WATER QUALITY RECOMMENDATIONS

- Homeowners using private well systems are encouraged to complete a visual inspection of their system and repair any visible damage immediately. If the well system was damaged by the fire a licensed well technician should inspect the system.
- If water tastes or smells earthy, smoky or burnt, flush the water lines again and test the water with a certified laboratory for routine well water quality parameters, including metals.
    - If water is contaminated:
        - Disinfect well with continuous chlorination or shock chlorination (preferred)
        - Disinfect by filtering using two-micron filter (activated carbon filter, ultrafilters, or reverse osmosis
        - Boil water for at least 1 minute
- If livestock appear to have signs of sickness an alternate water source should be provided and drinking source tested and treated.
- Irrigation water- use of settling ponds and the addition of linear polyacrylamide may be one solution for reducing excessive sediment and ash in irrigation water.

SEPTIC RECOMMENDATIONS

Onsite waste water septic systems are typically buried underground, so impacts from fire damage is often limited. Post fire flooding however may result in erosion of surface cover and damage to below ground components. Homeowners should inspect systems after flood events for damage to PVC piping above ground. If visible damage has occurred or if the system is malfunctioning (backing up), discontinue use and contact local health department for guidance and instruction on repair and restoration of the system.

Next Step Recommendations

A Multi Criteria Decisional analysis tool should be used to prioritize the potential treatments.

The Team recommends that a PLA be performed (Figure 3.34) to better understand the potential impacts, quantify impacts, and help prioritize projects for implementation. Landowners should utilize the PLA analysis to develop detailed conceptual plans for treatment recommendations and more accurately determine the sediment load reductions and cost estimates (Figure 3.35).

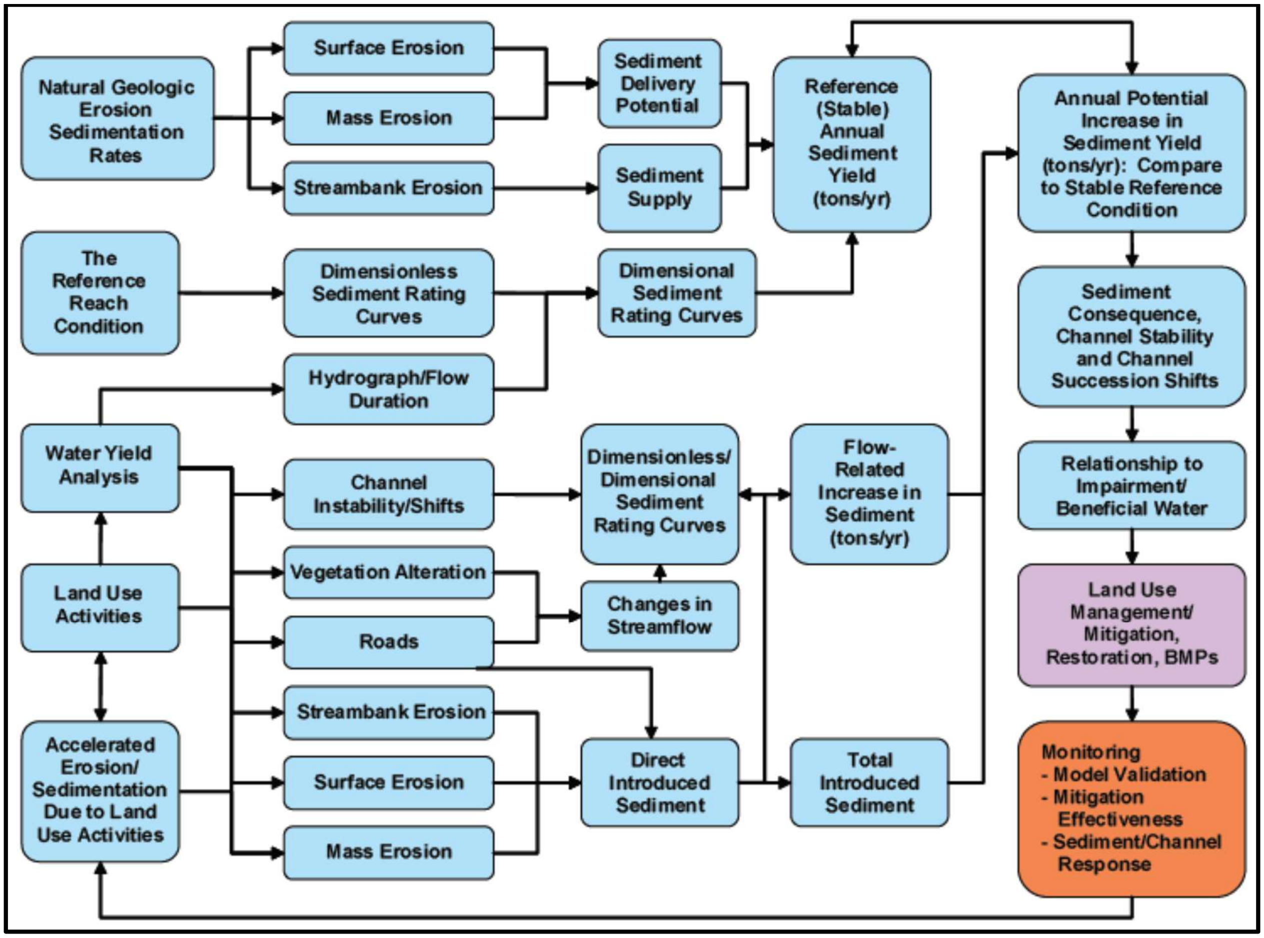

Figure 3.34. The general organization of the procedural sequence for the PLA (Rosgen 2006, 2009).

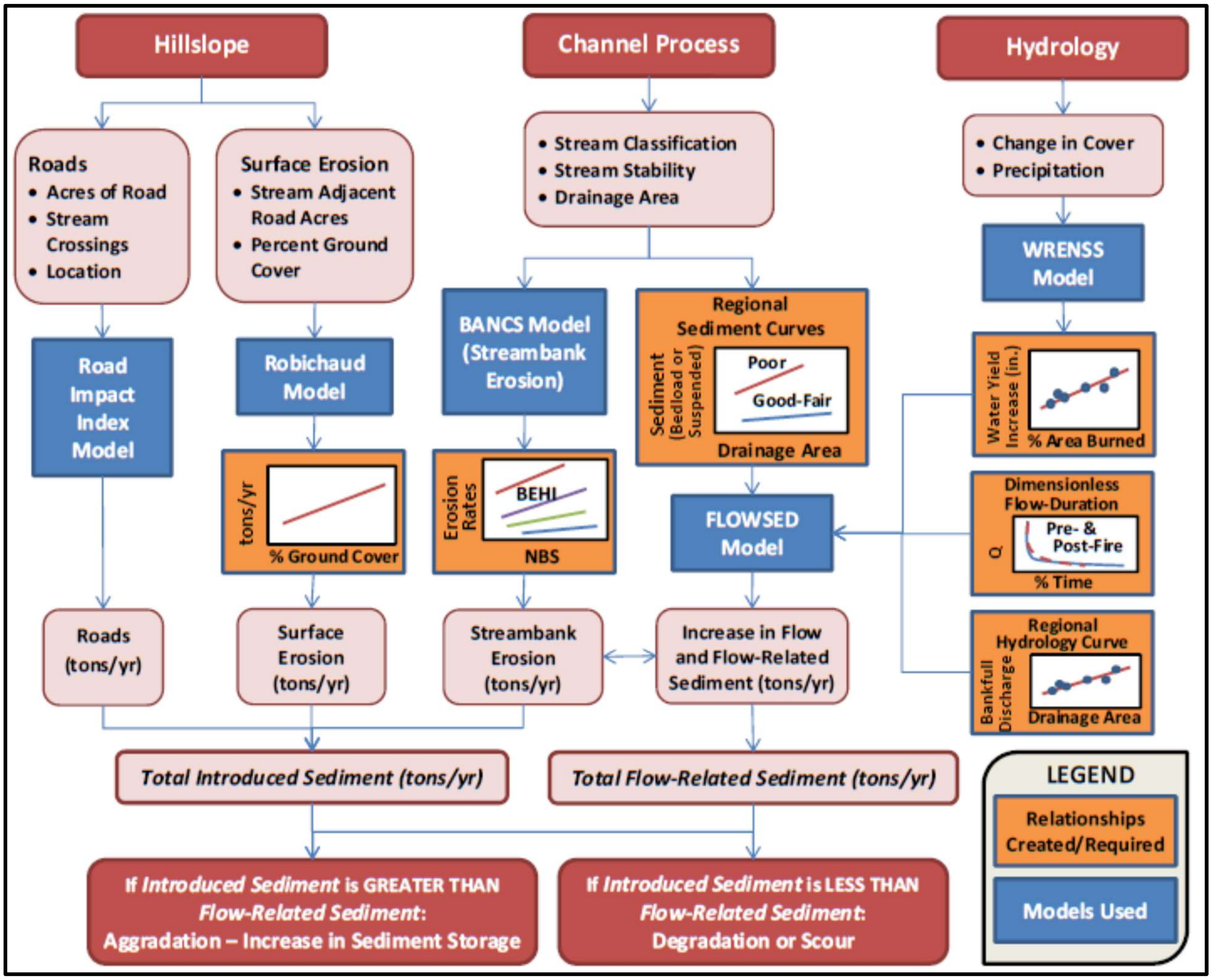

Figure 3.35. Procedural flowchart of the quantification of sediment sources and channel response utilizing a variety of models (Wildland Hydrology 2011).

River stability should be evaluated for each reference and representative reaches. The evaluation should be conducted on the reference reaches to validate a "Good" overall stability, and the data to be used in the departure analysis of the representative reaches compared to reference condition. The stable reference reach data and the representative reach characterizations should be stratified by stream type. The variety of reference and representative stream types and their existing morphological, hydraulic, and sedimentological characteristics that occur within the Ute Park Fire burn area should be summarized. Stratifying by stream type is necessary to extrapolate the established relationships elsewhere in the watershed based on similarity. Stream types are also stratified by valley types (Rosgen 1994, 1996, 2006, 2009) that integrate the boundary conditions and controlling variables responsible for a unique channel morphology and condition. A departure analysis of the representative reaches from their potential stable, reference reach condition is important in this assessment. The various stream types should be mapped by the major watersheds and sub-watersheds, and their corresponding stability and sediment relations.

Numerous models can be used in the river stability evaluation and departure analysis of the representative reaches from their potential reference reach condition (see Figure 3.35). Estimates of vertical and lateral stability, channel enlargement, and sediment supply, including channel competence and capacity evaluations, should be completed in the PLA phase. The BANCS model (Bank Assessment for Non-point source Consequences of Sediment [Rosgen 2001, 2006, 2009]) should be used to predict streambank erosion (tons/yr) and erosion rates (tons/yr/ft) for the reference reaches, representative reaches, major watersheds, and sub-watersheds. The BANCS model utilizes two tools to predict streambank erosion: 1) The Bank Erosion Hazard Index (BEHI), and 2) Near-Bank Stress (NBS). The BANCS model evaluates the bank characteristics and flow distribution along river reaches and maps BEHI and NBS risk ratings commensurate with streambank and channel changes. Annual erosion rates are estimated using the BEHI and NBS ratings, and then are multiplied by the bank height and corresponding bank length of a similar condition to estimate the tons of sediment per year.

Competence can be determined using the revised Shields relation for initiation of motion (Rosgen 2006, 2009). The FLOWSED and POWERSED models (as programmed in RIVERMorph™) could be used to analyze sediment yield and transport capacity to determine the bed stability (stable, aggradation or degradation) compared to the upstream sediment supply; the bed stability determination is based on the percentage of change between the upstream sediment supply and the sediment transport capacity of the existing condition. The POWERSED model uses only the suspended sand concentration, which is the hydraulically-controlled sediment transport, rather than total suspended sediment as used in FLOWSED. POWERSED would not run on the very steep gradient stream types; the many steep gradient stream types are at their potential stream type, and will always show excess energy due to their steep slopes and characteristic high sediment transport.

In addition, the PLA would continue to fine tune our TR-55 and ErMit models. Refining data sets and input parameters are necessary to better calibrate existing models. Different recovery scenarios may be applied to the ErMit model to help prioritize project areas and implementation. A predictive-level assessment would include calibrating the following variables to calculate delivered sediment from surface erosion and the increase in water yield:

- Percent Ground Cover
    - Total tree crown cover (TTCC) – Percent shrub
    - Percent forb
    - Percent grass
    - Percent barren
    - Percent water
- Satellite Burn Severity
- Treatments
    - Wood mulch
    - Straw mulch
- Presence of Rills (visual approximation from ground and aerial photos)
- Slope Shape (concave vs. convex)
- Slope Length
- Soil Texture
- Design storms
- Calibrate mannings “n” values
- BEHI surveys

In order to ensure that treatments applied to address post fire flooding and debris flows are successful, effectiveness monitoring is recommended. See Appendix A for more information on hydrological monitoring.

SOIL RESOURCES

This section summarizes fire and potential post-fire effects to soil resources and includes concerns relative to invasive plants and forest resources.

Due to the nature of the Ute Park Fire being a running crown fire the residence time fire had on the soil surface was limited. However, both the organic matter cover and the overhead canopy were consumed as a result of fire leaving the soils more susceptible to the erosive forces of water and wind. One of the key values at risk for soil resources is the loss of soil productivity due to the removal of the organic cover and the elevated erosion rates. The elevated erosion rates and subsequent sediment transport and deposition is a risk for other values at risk downstream if the soils cannot be stabilized.

Soil Burn Severity

Fire effects to soil resources are often identified by Soil Burn Severity (SBS) (see Figure 3.1). There are typically three severity categories assessed, and their arrangement and distribution mapped within the wildfire perimeter. The categories identified that were observed can be defined as follows:

High soil burn severity: About 36% of the area (13,047 acres) was determined to be in the high soil burn severity category. The canopy and understory were completely consumed and the litter layer was only partially consumed, due to the short residence time of the fire on the surface. The most severely burned slopes occur where pre-fire vegetation density and fuel accumulations were highest, these were typically on steep north-facing aspects and at the heads of watersheds.

Even under these conditions, soil structure was intact and unconsumed fine roots were present within the upper 4 inches of the mineral soil surface (Figure 3.36).

Figure 3.36. Presence of fine roots showing the soil structure is still intact.

Moderate soil burn severity: About 35% of the area (12,662 acres) was determined to be in the moderate soil burn severity category. In areas with moderate soil burn severity the herbaceous vegetation was consumed. Soil structure was intact and unconsumed fine roots were present within the upper 4 inches of the mineral soil surface.

Low soil burn severity: About 13% of forest and rangeland soils (4,745 acres) were determined to be in the low soil burn severity category. These burned over soils exhibited good surface structure, contain intact fine roots and organic matter, partially intact litter and duff layers, and are often already exhibiting recovery as grasses and forbs are visibly sprouting (Figure 3.37).

Figure 3.37. Low severity burn showing recovery as grasses and forbs are visibly sprouting.

Very Low/Unburned: About 16% of the area (5,928 acres) was determined to be burned at a very low intensity or unburned.

Water Repellent Soils

SWCA used the soil burn severity map (see Figure 3.1) produced by the U.S. Forest Service, to define the extent and location of the high soil burn severity areas in order to test for the presence of water repellency, or a measure of soil hydrophobicity. To determine the water repellency of the soils a drop of distilled water is placed on the exposed bare mineral soil surface. The time it takes for the water drop to infiltrate is measured. Slight to moderate soil hydrophobicity (water repellency) occurred in both moderate and high soil burn severity within both forest and rangeland. Strong (persistent) water repellency was observed in some moderate and high soil burn severities (Figure 3.38). Where observed, the water repellent layer generally occurred at the soil surface directly below the ash layer and partially consumed litter layer within 0.5 to 1.0 inch from the soil surface. Water repellent surfaces were also observed in some unburned areas. The majority of field observations indicated weak (low) repellency at the soil surface and to depths of 4 inches. Based on data collected in the field, the following was used to develop the following ratings:

- High soil burn severity areas showed strong water repellency, however, it was not continuous across the high severity areas as pockets of wetted soils persisted within the high severity areas.
- Moderate soil burn severity areas showed moderate water repellency, with very few areas of strong repellency. Like the high soil burn severity areas the water repellency was not continuous and there were large areas of wetted soils.
- Low soil burn severity areas and unburned areas had few areas of weak to no water repellency.

Figure 3.38. Strong water repellency observed in a high severity burn area.

Potential Physical, Chemical, and Biological Fire Effects on Soil Resources

Fire effects on soil productivity range from beneficial to catastrophic, depending on fire severity, soil type, and site history (Neary et al. 2005). Adverse fire effects increase as burn severity increases; the effects are often proportional to the residence time the fire is in the area and the amount of surface litter and soil organic matter consumed. The sensitivity of soils to fire effects is influenced by soil texture, soil moisture, organic matter content, rock content, soil depth, depth of surface layer, and erosion potential. Important and sensitive soil layers include soils formed under range vegetation. Ponderosa/grass and shrub sites have soils with thicker, humified layers compared to the soils formed under a mixed conifer vegetation type. Pre-fire soils in forested areas have important litter and duff layers protecting the mineral soil surface. Loss of these layers due to erosion can reduce soil productivity and can contribute to sedimentation. Damages to the soils as a result of the Ute Park Fire can be broken into physical, chemical, and biological effects and are summarized below.

Physical Effects:

- Loss of litter and duff layer, soil, and soil organic matter

- Hydrophobicity (formation of water repellent layer)

Chemical Effects:

- Increase in pH
- Loss of cation exchange capacity
- Loss of nutrients by volatilization, in fly ash, or by leaching
- Increase plant available N (ammonia) under low severity burns
- Oxidation reactions from extremely severe burning can discolor the surface soil
- Potential for increased release of heavy metals in contaminated soils

Biological Effects:

- Direct mortality of soil micro and macro organisms and loss of their habitat with soil heating

Many of the impacts to soils discussed above were not seen extensively across the burn scar as residence time of the fire on the ground was limited due to the fast-moving crown fire that occurred. This resulting short residence time of fire on the ground surface helped mitigate some of the severe impacts that can come from prolonged soil heating.

Debris Flows, Landslides, and Rock Falls

Post-fire landslide hazards include fast-moving, highly destructive debris flows, landslides, and rock falls. These events can occur directly following fire and in the years immediately after wildfires in response to high intensity rainfall events, and flows that are generated over longer time periods that are accompanied by root decay and loss of soil strength. These post-fire events are particularly hazardous because they can occur with little warning, can exert great loads on objects in their paths, can strip vegetation, block drainage ways, damage structures, and endanger human life.

Post-fire debris flows are most common in the 2 years after a fire and they are usually triggered by heavy rainfall. Flooding and increased runoff may continue for several years, but it is unusual for post-fire debris flows to be produced beyond the second rainy season. Some of the largest debris-flow events have been triggered by the first intense rainstorm of the storm season. It takes much less rainfall to trigger debris flows from burned basins than from unburned areas. In southern California, as little as 7 millimeters (0.3 inch) of rainfall in 30 minutes has triggered debris flows, which was the amount of rainfall that was estimated that triggered the debris flow in Ute Park (Figure 3.39 and Figure 3.40). USGS research has shown any storm that has intensities greater than about 10 millimeters/hour (0.4 inches/hour) is at risk of producing debris flows.

The USGS modeled debris flow probability map in Figure 3.41 shows the watersheds above Ute Park being at moderate risk for debris flows. This coupled with the historical deep-seated landslide deposits results in a significant risk to downslope infrastructure (see Figure 3.39 and Figure 3.40). The landslide susceptibility map (see Figure 3.33) that was developed by the New Mexico Bureau of Geology and Mineral Resources, refers only to the propensity of a portion of the landscape to fail as a landslide, irrespective of driving forces such as heavy precipitation or earthquakes (Cikoski and Koning 2017). Appling material to cover the bare mineral soil along with vegetative regrowth should help limit future events, however, this area will still be susceptible for years to come as the watersheds recover. Having an alert system that would warn residences down below this area is critical to ensure public safety, as preventing debris flows and landslides is typically not possible or financial feasible the first year following fire.

While multiple factors can affect debris-flow occurrence, post-fire debris flows generally are triggered by one of two processes: surface erosion caused by rainfall runoff, and landslides caused by infiltration of rainfall into the ground. Surface erosion runoff processes are by far the most prevalent contributor to debris flows. This is because fires commonly reduce the rate at which water can seep into the soil, which increases runoff and erosion. Landsliding processes are much less common causes of fire-related debris flow, but prolonged heavy rains may increase soil moisture even after a wildfire. **Error! Reference source not found.** in the above section shows the areas at highest risk of landslides following the fire. The wetted soil then may fail, producing infiltration-triggered landslides. Wildfires can also result in the destabilization of pre-existing deep-seated landslides over long time periods.

Figure 3.39. Photograph of debris flow that impacted Ute Park on July 13–14, 2018.

Figure 3.40. Photograph of large material that was mobilized during the debris flow that impacted Ute Park on July 13–14, 2018.

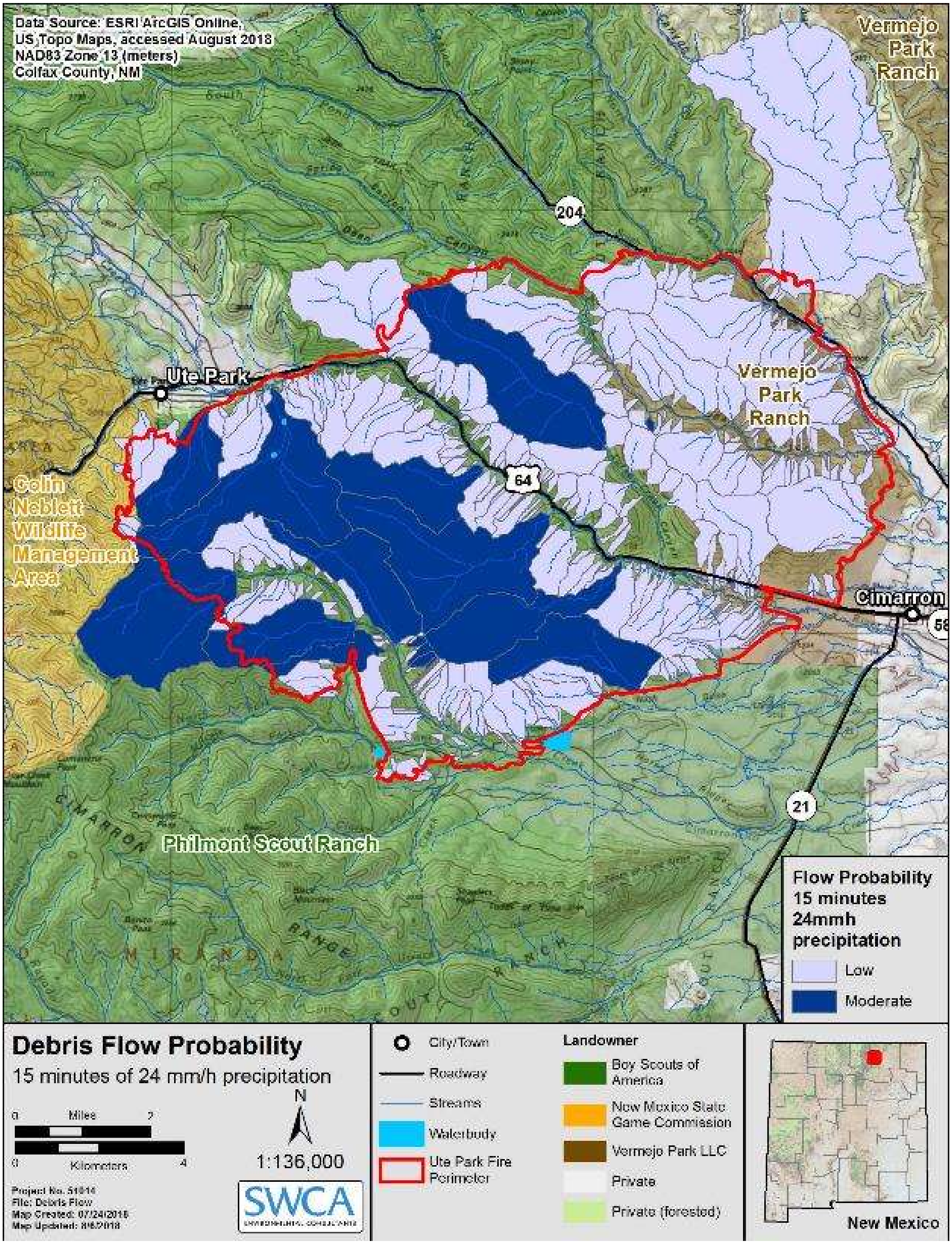

Figure 3.41. Map showing areas of greatest risk to debris flows from USGS modeling.

Recommendations for Stabilizing of the Soils

The private BAER team undertook a comprehensive exercise to identify critical values at risk. Soil productivity was identified to be a resource at high risk due to the erosion potential. Treatments to address these values include both emergency measures and more long-term actions. A summary of recommended treatments for soil rehabilitation is presented in Table 1.4 on page 15.

Treatments and rehabilitation actions were identified and developed using examples and guidance provided by the NRCS in technical publications and in the Burned Area Emergency Response Treatments Catalog (Napper 2006).

It should be noted these are recommendations and other approaches may be used to meet objectives based on the priorities of the individual landowners. The areas suggested for treatment are located above critical values at risk that include the community of Ute Park, municipal and agricultural water infrastructure, transportation infrastructure, and property and life. Figure 3.42 below highlights areas in need of treatment immediately and as well as the types of treatments suggested. The overall goals for treatment of the soil resources are to stabilize soils to reduce the transport of sediment downstream towards critical infrastructure and minimize the spread of noxious weeds while native vegetation is becoming reestablished.

Treatment areas for soil stabilization applications were selected based on several criteria:

- Critical Values at risk lower in watershed
- High soil burn severity areas prone to sheet and rill erosion
- Areas that show signs of slow regeneration of native cover
- High severity areas with south-facing slopes up to 40%
- Location to active stream channels
- Ability to access sites safely

The primary treatments recommended for soil hillslope stabilization include wattle/fiber rolls placed along the hillslope contours, log erosion barriers (Figure 3.43), spreading of slash/mulching, and seeding with native species. Treatment protocols developed by the U.S. Forest Service and NRCS are provided in Appendix F and should be followed when implementing treatments. The Ute Park Fire was a fast-moving crown fire that largely left the soil resources and associated seed bank intact. The treatments recommended are designed to help reduce erosion by shortening the slope length to slow overland flow velocity, and provide an organic and herbaceous cover that limits the erosive forces of water and wind.

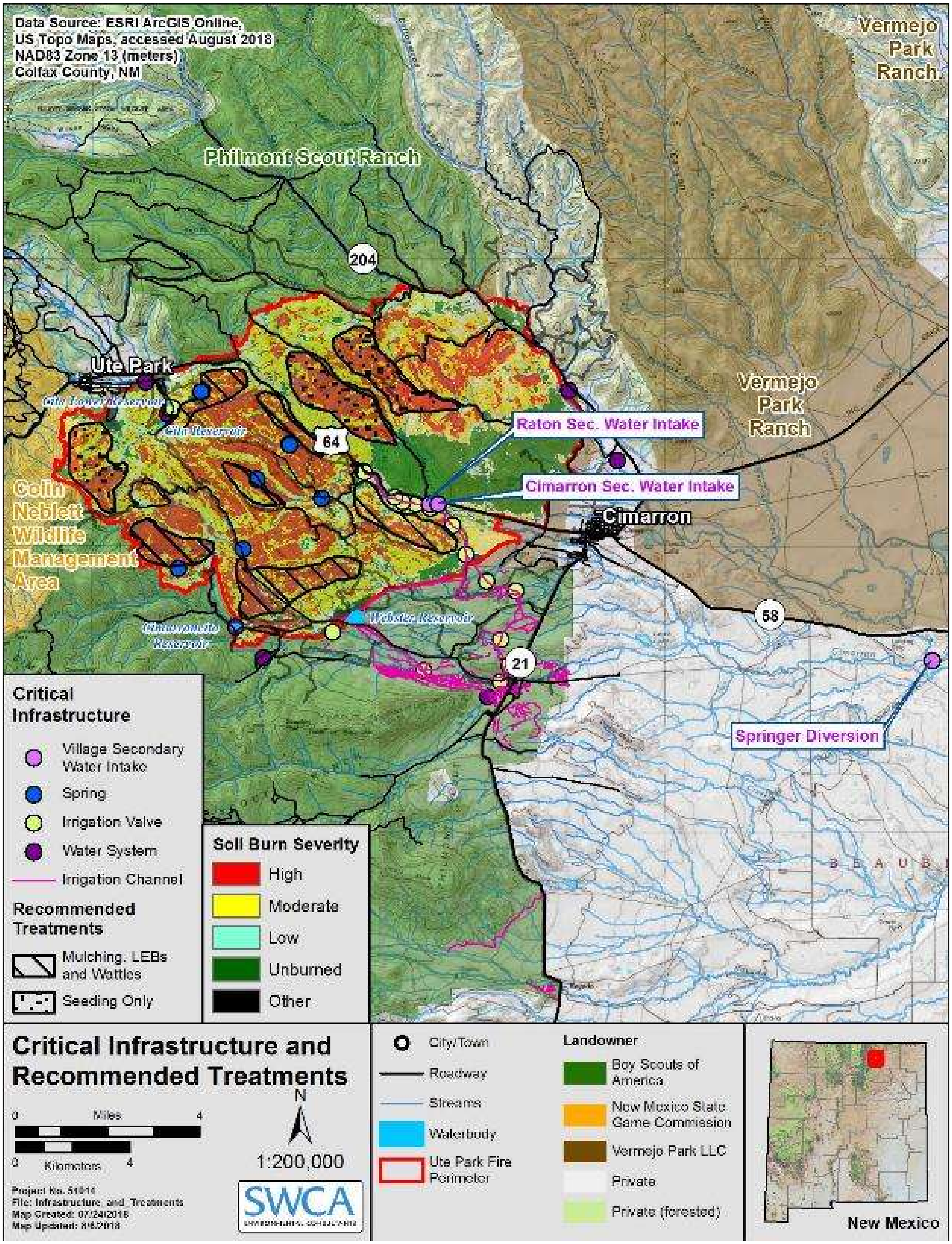

Figure 3.42. Recommended treatment locations for stabilizing hillslope soils.

Figure 3.43. Log erosion barriers installed above Cimarroncito intake structure on Philmont Scout Ranch.

Wattle/Fiber Rolls

Wattles, whether they are straw or woodchips, help trap sediment and provide a seedbed for vegetative recovery. Where water repellant soils are present, the installation of the wattles may break through the water repellant layer and can improve infiltration. In order for wattles to function properly, they need to be installed following guidelines provided from the U.S. Forest Service BAER Catalog or NRCS technical publications (Appendix D). It is important to note that wattles are not for stream channels or gullies. A benefit of wattles is that they can accomplish similar result as log erosion barriers, but require less skilled labor to install and can be placed on the slope more effectively. Wattles should be focused on south-facing slopes of less than 40%, particularly the south-facing slopes above the Cimarron River called the bench area.

Log Erosion Barriers (LEBs)

Log erosion barriers (LEBs) have been shown to be effective treatment at capturing sediment; however, if not done properly, these structures can create more ecosystem damage through concentrated flows and increased sediment leaving the site. This method requires felling trees on slopes, so safety should be the number-one priority. When installing LEBs, if the strict guidelines provided by the U.S. Forest Service and NRCS are followed, failures can be limited. LEBs are recommended to be done in the first year following the fire. As time goes on, trees become less stable and can fall and break at any time, which makes LEBs not worth the risk. LEBs should be focused on slopes of less than 40%, particularly the south-facing slopes above the Cimarron River, called the bench area. Figure 3.42 highlights the priority areas for LEB placement.

Spreading of Slash/Mulching

Spreading of slash/mulching is another method that will help with reestablishing an organic cover on the bare mineral, reduce erosion, and increase soil moisture for longer periods of time following precipitant events. Spreading of slash/mulching areas after fire can done by hand, with a mobile chipper, or masticator. A mobile chipper is recommended in areas where vehicle access is not an issue and biomass is available to cut and chip, like along roadways where hazard trees exists. The preferred method for spreading of slash/mulching is the use of a masticator/hydro ax. Masticators are machines with teeth attached to either a rotating drum or spinning disc that comprises a masticating head. This head breaks litter and slash as well as smaller trees down into small pieces. Masticating heads can be attached directly to the frame of the machine or on the end of a boom. Mastication reduces fuel height and fuel size but does not remove vegetation from the site. Masticators are also capable of spreading both standing biomass as well as biomass on the surface. This type of equipment can cover a large areas and access sites vehicles cannot. It is most commonly used in sapling-sized conifers and pinyon-juniper vegetation types.

As seen in Figure 3.42 above, treatments are generalized treatment blocks and are targeted in areas where the most critical values at risk and threats to life and property exist.

Lastly, it is recommended at the start of hillslope stabilization projects that an application of certified weed-free native seed should be spread around the treatment area. Seeding disturbed areas helps control noxious weeds and prevent weed spread and also provides a secondary long-term benefit of soil stabilization. The native seed mix that is recommended in the vegetation treatments of this report or by the NRCS should be used in priority areas. Apply seed mix in accordance with NRCS Conservation Practice Standard Code 342, Critical Area Planting, which will help ensure successful seeding:

- Seeding should occur in concert with other hillslope restoration measures or in late fall or early winter to facilitate early establishment and take advantage of fall and winter moisture.
- Application can be broadcast on snow surface.

In order to ensure that treatments applied to prevent soil erosion and limit potential debris flows are successful, effectiveness monitoring is recommended. See Appendix A for more information on soil monitoring.

VEGETATION

Post-fire Vegetation Condition Assessment

A post-fire assessment of vegetation conditions of the burn area was conducted from July 12 through 14, 2018 by SWCA personnel. The assessment including an aerial drone reconnaissance to document canopy conditions, and an on the ground ocular assessment of understory and overstory stand conditions. Understory vegetation was burned off over most of the high severity burns, and over much of the moderate-severity burns. However, organic litter and duff was still present in many of the high- and moderate-severity areas, at least in patches. Much of the root crowns of perennial grasses were still intact and live in low-severity burns.

Given the patchy nature of burn severity, with intermixing of high, moderate, low and unburned (Figure 3.44 through Figure 3.48), natural understory vegetation recovery should proceed with new growth (Figure 3.49). The soil seed bank appeared to be largely intact based on the presence of scorched but not completely burned plant leaf litter and duff on soil surfaces, even in high- and moderate-severity burn areas. Additionally, unburned plants from adjacent and upslope unburned patches should provide additional natural seed dispersal to adjacent high- and moderate-severity burn areas.

Figure 3.44. Aerial photograph of low severity burn area taken using drone reconnaissance, showing intact green tree canopy.

Figure 3.45. Aerial photograph of moderate severity burn taken using drone reconnaissance, showing extensive scorch to overstory trees.

Figure 3.46. Aerial photograph of moderate to high severity burn taken using drone reconnaissance, showing the majority of the tree canopies were entirely consumed, but some trees have retained scorched needles.

Figure 3.47. Aerial photograph of stock pond in high severity, stand replacement portion of the burn that has been colonized by sunflowers.

Figure 3.48. Aerial photograph of high severity burn area taken by drone reconnaissance over Turkey Creek; light ash on the ground surface suggests intense heating of soils, litter, and duff.

The frequency, intensity and duration of 2018 and 2019 summer rains will be key to post-fire recovery of understory vegetation. If rains are frequent with low intensity and high duration, natural vegetation should be good. Otherwise, natural revegetation may be slow if soils do not maintain sufficient moisture for seed germination, and growth of surviving perennial grasses, forbs and shrubs from root crowns. The above observations were consistent across elevations from just above Cimarron to Ute Park, on various slopes and aspects, and across different forest stand types from pinyon-juniper to ponderosa pine and mixed conifer.

Riparian areas also experienced variable burn severity, but vegetation immediately along the Cimarron River appeared to be less damaged than in adjacent conifer woodlands on slopes. While surrounding slopes experienced moderate to high-severity fire, the immediate riparian zone appeared to have experienced more moderate-severity burn. Willows including coyote or arroyo willow and peachleaf willow were still alive in many places (Figure 3.50), even if the leaves had been scorched. Larger cottonwood, ash, alder and Gambel oak trees were scorched, but many riparian oaks were re-sprouting from roots, and cottonwood and ash trees may resprout as well. The greatest post-fire threat to the riparian vegetation is likely to be flooding and sedimentation resulting from runoff and soil erosion on steep burned slopes above the Cimarron River and other streams and drainages.

Figure 3.49. New growth of cactus pad in a low severity burned grassland area.

Figure 3.50. Vegetation recovery already observed along many riparian areas.

As of July 12–14, 2018, perennial grasses such as western wheatgrass, blue grama, galleta, and big bluestem had already started producing new leaves from their rootcrowns in many of the moderate and some high-severity burn areas (Figure 3.51). Gambel oak had begun to produce stems and leaves from root crowns in high- and moderate-severity burn areas (Figure 3.52). Earthstar fungus fruiting bodies had recently developed on burned soil surfaces of a high-severity burn, indicating that lethal fire heat did not penetrate deep into the soils (Figure 3.53).

Figure 3.51. Grass recovery in basin burned with high severity.

Figure 3.52. Basal sprouting of Gambel oak.

Figure 3.53. Earthstar fungus fruiting bodies.

Risk of Non-native Plant Species and Noxious Weed Infestation

Exposed soil surfaces resulting from the fire provide ideal environments for non-native and noxious weed (weeds) plant species to become established, where native vegetation cover has been reduced or eliminated. Such establishment and spread of weed plant species is especially likely in high-severity burn areas, and along existing roads and other previously disturbed areas were resident populations and seed sources already exist for weeds to disperse on to burned soils. Best management practices also must be employed for soil, vegetation and engineering post fire rehabilitation activities, to reduce the potential transportation of weed seeds into treated areas.

The New Mexico Department of Agriculture (2016) categorizes listed noxious weeds into four categories based on current distribution and recommended management needs. Class A species do not yet occur in New Mexico, or have very limited local distributions, and are highest priority for prevention management. Class B species have limited distributions in the state and have high priority for prevention management. Class C species are wide-spread across the state, with moderate priority for prevention management. Watch List Species are of concern, but not enough is known about them to advise management. There are 20 Class A species listed, 11 Class B species listed, 12 Class C species listed, and seven Watch List Species listed for New Mexico (New Mexico Department of Agriculture 2016). New Mexico State listed noxious weed species that are known or likely to occur in the Ute Park burn area are listed in Table 3.4, along with suitable habitat and management objective information.

Table 3.4. New Mexico State Listed Noxious Weeds that May Require Management for the Project

Species	Rank Status	Suitable Habitat	Management Objective*
Canada thistle (*Cirsium arvense*)	Class A	Disturbed soils along roadsides, pastures, riparian areas	Eradicate
Hoary cress (*Cardaria* spp.)	Class A	Disturbed soils along roadsides, pastures, riparian areas	Eradicate
Leafy spurge (*Euphorbia esula*)	Class A	Disturbed soils along roadsides, pastures, riparian areas	Eradicate
Oxeye daisy (*Leucanthemum vulgare*)	Class A	Disturbed soils along roadsides, pastures, riparian areas	Eradicate
Spotted knapweed (*Centaurea biebersteinii*)	Class A	Disturbed soils along roadsides, pastures, riparian areas, and burn scars	Eradicate
Bull thistle (*Cirsium vulgare*)	Class B	Disturbed soils along roadsides, pastures, riparian areas, and burn scars	Control, manage
Chicory (*Cichorium intybus*)	Class B	Disturbed soils along roadsides, pastures, riparian areas, and burn scars	Control, manage
Perennial pepperweed (*Lepidum latifolium*)	Class B	Disturbed soils along roadsides, pastures, riparian areas, and burn scars	Control, manage
Poison hemlock (*Conium maculatum*)	Class B	Disturbed soils along riparian areas	Control, manage
Quackgrass (*Elytrigia repens*)	Class B	Disturbed soils along roadsides, pastures, riparian areas, and burn scars	Control, manage
Russian knapweed (*Acroptilon repens*)	Class B	Disturbed soils along roadsides and pastures, and burn scars	Control, manage
Spiny cocklebur (*Xanthium spinosum*)	Class B	Disturbed soils along roadsides, pastures, riparian areas, and burn scars	Control, manage
Teasel (*Dipsacus fullonum*)	Class B	Disturbed soils along roadsides, pastures, riparian areas, and burn scars	Control, manage

Species	Rank Status	Suitable Habitat	Management Objective*
Cheatgrass (*Bromus tectorum*)	Class C	Disturbed soils along roadsides, pastures, riparian areas, and burn scars	Control, manage
Eurasian watermilfoil (*Myriophyllum aquaticum*)	Class C	Streams, ponds, stock tanks; aquatic only.	Control, manage
Musk thistle (*Carduus nutans*)	Class C	Disturbed soils along roadsides and pastures, and burn scars	Control, manage
Russian olive (*Elaeagnus angustifolia*)	Class C	Riparian areas	Control, manage
Saltcedar (*Tamarix* spp.)	Class C	Riparian areas	Control, manage
Siberian elm (*Ulmus pumila*)	Class C	Disturbed soils along roadsides, pastures, riparian areas, and burn scars	Control, manage
Tree of heaven (*Ailanthus altissima*)	Class C	Disturbed soils along roadsides, pastures, riparian areas, and burn scars	Control, manage

* Management objectives are from the New Mexico Department of Agriculture (2016).

In addition to the New Mexico state listed noxious weeds, there are many other exotic and invasive species that are not listed as noxious weeds. While such other exotic and invasive species may or may not pose threats to natural plant communities and special status plant species, all are undesirable and their introduction and spread should be prevented. Any exotic plant species represents a potential competitive threat to any native plant species for habitat space, soil water, soil nutrients, and sunlight. Federal Executive Order 13112 requires all federal agencies to manage resources in ways such as to minimize the introduction and spread of exotic species, and to employ management actions to control exotic plant species should they become established due to federal actions.

Management objectives within the burn area should be to control and/or eradicate all noxious weeds. To comply with Executive Order 13112, and to serve as good stewards of the land, weed management also should target any exotic and invasive plant species that is found to colonize soils disturbed by the fire or post-fire rehabilitation actions, with the management objectives of containing and controlling any local infestations. In most cases, noxious weed management will by default, also be affective against other exotic invasive plant species.

The most common weed species observed on the post-fire July 13 and July 14 field evaluation of the burn area included cheatgrass, Japanese brome, and field bindweed, all observed growing along roadsides in unburned situations throughout the burn area. Field bindweed was observed sprouting from roots on moderate and light-severity burned soils throughout the burn area as well.

Rehabilitation and Restoration Recommendations for Understory Vegetation

Given the relatively intact subsurface soil conditions, and the patchy nature of the fire, rehabilitation may only be needed on steep slopes (>30%) that were burned by high-severity fire, and that are in watersheds that pose a threat of flooding and debris flows to structures and water resources. Any areas that are targeted for soil, hydrology, and engineering rehabilitation also should include understory vegetation seedings. The primary areas where rehabilitation of understory vegetation may be needed are the burn scars on steep slopes above Ute Park, which has already suffered a catastrophic debris flow (Figure 3.54), those above U.S. Highway 64 in Cimarron Canyon, and in the watershed of Turkey Creek. Recommended seed species include the native perennial grass sand dropseed (*Sporobolus cryptandrus*) which is an early successional colonizer of bare soils in the region, and annual sunflower (*Helianthus annuus*), which is also is a native early colonizer species of bare soils in the region. Both species were observed in and around the burn area. These species should be seeded in mid-summer of 2018, but the time to obtain and distribute the seeds may be too late for 2018. In that case, these plants could be seeded in early summer of 2019, along with the other species recommended for restoration below. Table 3.5 shows costs associated with aerial seeding of these plant seeds for rehabilitation purposes.

Figure 3.54. Photograph showing the size of material mobilized during the debris flow above Ute Park. Slope stabilization is a priority for the drainage and slopes in that area.

Restoration of understory plant species should be initiated in the late spring or early summer of 2019. The primary purpose of understory vegetation restoration is to enhance soil surface cover and reduce soil erosion, and to provide habitat for wildlife. Restoration treatments should be initiated on the same areas where vegetation rehabilitation is employed, to further enhance the stabilizing function of herbaceous vegetation cover for exposed soils on steep slopes. Other restoration treatments should be employed in extensive high- and moderate-severity burns, but in a patch pattern to create initial plant growth and seed sources for the future expansion of understory vegetation. Recommended species include those recommended above for vegetation rehabilitation, along with other native perennial grasses and forbs that occur in the area (western wheatgrass [*Pascopyrum smithii*], blue grama grass [*Bouteloua gracilis*], and Galleta grass [*Pleuraphis jamesii*]), and a shrub species such as four-wing saltbush (*Atriplex canescens*), which is an early colonizer shrub species in the burn area (Figure 3.55). All plant species chosen for restoration will be species that already occur in the area, and that wildlife use for habitat. Table 3.6 shows costs associated with aerial seeding of these plant seeds for restoration purposes.

Figure 3.55. Native perennial herbaceous species recovery in moderate severity portion of the burn area.

Non-native grasses such as Italian rye and Kentucky bluegrass should not be used for rehabilitation or for restoration. Those non-native species will become established and outcompete the variety of native perennial grass species that occur in the area and should be used for rehabilitation and restoration seedings. For example, seeded non-native Kentucky bluegrass is known to outcompete native Arizona fescue when exposed to livestock grazing (Dick-Peddie 1993). A complex of native grass species will result in a diverse and healthy vegetation community for wildlife and will increase the resistance and resilience of the burn area to future environmental disturbances such as wildfire and drought.

Table 3.5 identifies recommended native annual and perennial plant species to aerially seed for rehabilitation of soils on high-severity burn areas on steep slopes (>30%) above infrastructure or important watershed resources (e.g., steep high-severity burned slopes above Ute Park, U.S. Highway 64, and in Turkey Creek Canyon) that sum to 830 acres. These plant species should be seeded in August–September 2018, but that may be unreasonable due to logistics. They are warm season species that would germinate in early to mid-summer, depending on summer rains. They would provide initial soil surface cover, and forage and flowers for wildlife and pollinators. These plant species are native early successional colonizers of disturbed areas in the burn area region. Recommended seed amount/acre and seed costs are based on a July 2018 quote from a New Mexico seed supplier.

Table 3.5. Recommended Native Annual and Perennial Plant Species to Seed for Rehabilitation of Soils on Steep Slopes above Infrastructure or Important Watershed Resources

Plant Species	Seeding Time	Pounds/ acre alone	Pounds/ Acre in mix	Seed Cost/ Pound	Seed Cost/ Acre	Seeding Cost/ 830 Acre	Aerial Seed Application Cost ($50.00/acre)	Total Cost
Sand dropseed grass (*Sporobolus cryptandrus*)	Mid-summer 2018 or early summer 2019	2	2	$5.50	$11.00	$9,130.00	$41,500.00	
Annual sunflower (*Helianthus annuus*)	Mid-summer 2018 or early summer 2019	10	2	$8.00	$16.00	$13,280.00	One application, see above	
Totals			**4**	**$13.50**	**$27.00**	**$22,410.00**	**$41,500.00**	**$63,910.00**

Table 3.6 identifies recommended native annual and perennial plant species to aerially seed for restoration of soils on high-severity burn areas on steep slopes (>30%) above infrastructure or important watershed resources (e.g., steep high-severity burned slopes above Ute Park, U.S. Highway 64, and in Turkey Creek Canyon) that sums to 830 acres. Along with those plants listed in Table 3.5 above, and seeded in 2018 or 2019, these plants would germinate and grow during the summer of 2019. All of these plants are perennials, and would colonize burned areas over a 1- to 3+ year period. These plants would provide additional soil cover and wildlife habitat. All of these plant species are native to the burn area region. Costs are based on a July 2018 quote from a New Mexico seed supplier.

Table 3.6. Recommended Native Perennial Plant Species to Seed for Restoration of Soils and Wildlife Habitat on High-Severity Burned Slopes throughout the Burn Area

Plant Species	Seeding Time	Pounds/ acre alone	Pounds/ Acre in mix	Seed Cost/ Pound	Seed Cost/ Acre	Seeding Cost/ 830 Acre	Aerial Seeding Cost ($50.00/acre)	Total Cost
Western wheatgrass (*Pascopyrum (Agropyron) smithii*)	Spring 2019	10	5	$5.25	$26.25	$9,975.00	$41,500.00	
Blue grama grass (*Bouteloua gracilis*)	Early-summer 2019	3	2	$10.00	$20.00	$7,600.00	One application; see above	
Galleta grass (*Pleuraphis (Hilaria) jamesii*)	Early-summer 2019	5	2	$22.50	$45.00	$17,100.00	One application; see above	
Four-wing saltbush (*Atriplex canescens*)	-summer 2019	8	2	$10.00	$20.00	$7,600.00	One application; see above	
		Total	**11**	**$47.75**	**$111.25**	**$42,275.00**	**$41,500.00**	**$83,775.00**

Vegetation Restoration for Wildlife Habitat

Large animals such as deer, elk and black bear were observed moving into the periphery of the burned areas on July 13 and 14, 2018 (Figure 3.56), and tracks were observed well into burn scars, indicating that large animals that escaped the fire are already beginning to move back as remaining habitats will allow. The patchy nature of the fire left numerous unburned patches that likely provided refuge for small animals within the overall fire perimeter (Figure 3.57). Vegetation restoration described above should be conducted in such a way as to initiate the process of natural vegetation recovery with supplemental seeding and plantings of native plant species that will provide habitat for wildlife. In addition to native grasses and forbs, seed plantings of browse shrubs are important to restore wildlife habitat. Wildlife habitat restoration will take at least 10 to 30 years, and efforts to do so should begin as soon as possible. Again, only native plant species should be used for rehabilitation and restoration to create diverse and healthy habitats for wildlife.

Figure 3.56. Deer observed within a high severity section of the burn area.

Figure 3.57. Patchy burn severity left many areas of intact overstory and understory species.

Forestry Resources

This section is focused on long-term restoration of the different forested environments over the landscape. Immediate actions on forest recovery are not needed but the sooner a landowner starts the process, the faster the trees will recover.

Vegetation communities such as forests and woodlands are landscape scale, or geographic assemblages or associations of plant species that are composed of particular dominant indicator species that distinguish such communities from other adjacent plant communities. The suite of plant species that occur in any given vegetation community are adapted to the environmental conditions that exist on the landscapes where given vegetation communities occur. Different, adjacent vegetation communities are in turn composed of different plant species that are adapted to different environments. Different plant communities occur in, and are adapted to different environments, and therefore, respond in different ways to various forms of environmental disturbance or change. Most vegetation communities undergo a dynamic process of species composition changes following environmental disturbance, called plant succession. Typically, certain colonizer plant species occupy disturbed areas largely devoid of late successional vegetation, those plant species then change the environment further over time, leading to a succession of changes in plant species compositions until a final or climax successional stage is reached. The vegetation communities are generally classified based on the composition of dominant species at the climax stage of succession.

A forest landscape produced from fire disturbance over a span of different times, different parts of the landscape and from different intensity burns will have a high diversity of different forest stand species compositions and structural types. A large forest will have numerous stages of succession, including early, mid, and late succession stages. Through each of these stages, different plant communities will dominate the forest area. Each stage of succession will have a different look and a different benefit to the forest community. One change that will be noticed is a change in wildlife species present, as each species may depend on a specific stage of forest succession to survive. Following a wildfire, an early succession forest will have lots of dead trees, new grasses and shrubs growing under the dead trees. Cavity nesting birds will thrive in this environment as well as animal species that enjoy browsing on grasses and shrubs. These animal species could be wildlife or domestic species. Areas that burned at low intensity will stay in their current succession stage and continue to a late succession stage until a moderate or intense burn starts the process of succession at the beginning again.

How the forests recover after a wildfire season is affected by the intensity of the wildfire and severity of fire effects, as well as the capabilities of the land and its associated plants and animals to respond to the wildfire.

Low Severity Burn areas

In these areas, the trees will have a high chance of survival and tree mortality is expected to be low. The characteristics of these areas are:

- Where bunch grasses were present before the fire, more than 50% crown roots are alive and grasses should grow back.
- Shrubs leaves will be dead but remain on the plants.
- Between 0 and 50% of coniferous tree crowns will be scorched, but long-term survival will be relatively high.
- Ground cover will have a mixture of live vegetation, litter, duff, and bare ground present (Figure 3.58).

Figure 3.58. Low severity surface burn on Philmont Scout Ranch.

Moderate Severity Burn areas

In these areas the trees will have a mixed chance of survival. A majority of the trees will not survive the effects of the fire but a certain percentage will. A typical tree that survives will be thick bark trees such as ponderosa pine and Douglas fir. They will generally have 60% or less crown and bole scorch. Due to the reduced crowns in the surviving trees, the trees will be under extra stress. Additional tree mortality will be expected over the next several years due to this stress. This mortality will often be caused by bark beetle's seeking out these stressed trees. The characteristics of these areas are:

- Where bunch grasses where present before the fire, less than 50% crown roots are alive and grasses will grow back.
- Shrubs will be missing leaves and small twigs or just stems remaining.
- Conifer tree crowns will have scorch between 50% and 100%, but typically the needles will be brown and still attached to the trees (Figure 3.59)
- Ground cover will be a mixture of litter, duff, and bare ground. Some live vegetation may be present.

Figure 3.59. Moderate severity burn area showing some green leaves among fully scorched trees. Some grass recovery is evident.

High Severity Burn areas

Nearly all trees will be dead in high intensity burn areas. The characteristics of these areas are:

- Where bunch grasses are present, less than 30% crown roots are alive and no to very limited grasses will grow back.

- Shrubs will just have the stubs remaining, but root systems still intact.
- Conifer tree crowns will generally be black, with no to little needles present (Figure 3.60).
- Ground cover will include some blackened litter and duff, but most of the area will be bare ground.

Figure 3.60. High severity burn area above Turkey Creek.

Mixed Severity Fire Effects

The Ute Park Fire burned with mixed severity, with many areas lightly burned in the understory with intact overstory vegetation (Figure 3.61). In some places low severity burn was found immediately adjacent to areas that experienced high severity stand replacing fire effects. This results in a mosaic of stand structures with areas of intact seedbanks that will over time help in the recovery and regeneration of forest species in adjacent high severity burned areas. Even in some high severity areas, initial recovery of understory shrub species like Gambel oak has already begun Figure 3.62.

Although regeneration of some forest communities like ponderosa pine and Douglas-fir may take several decades, these early successional species will provide ground cover and stabilization to the soil resource. In the long term the species composition of these communities should return to pre-fire conditions.

Figure 3.61. Low severity, understory burn in open ponderosa pine stand.

Figure 3.62. Gambel oak resprouts in an area of high severity stand replacement.

Reforestation

Due to the dominance of ponderosa pine in the burn area, the following information is specific to that species.

Studies have shown that post-fire regeneration of ponderosa pine in the southwestern United States is slow, episodic, and difficult to predict (Ouzts et al. 2015). Ponderosa pine seeds disperse within about 1 to 1.5 times the parent tree height (Lentile et al. 2005), with research showing that at distances of greater than 50 meters from live trees, natural regeneration begins to decline (Chambers et al. 2016). Therefore, after a fire, if there are large patches of forest that burned with stand-replacing severity, the potential for natural regeneration may be limited. Even where there are seed trees available, site conditions for germination may also limit success. Ponderosa pine seedlings need intermediate shade conditions for good establishment (Bonnet et al. 2005), which includes the presence of scorched needle litter on blackened mineral soil and low vegetation cover (Bonnet et al. 2005). Successful reproductive output requires that ponderosa pine seeds need moisture within the soil (Bonnet et al. 2005); therefore, natural regeneration is often slower on steeper, south-facing sites (Hibbs and Jacobs 2011). The presence of scorched needles on the soil surface increases soil moisture retention (Bonnet et al. 2005). Litter consisting of recently fallen needles, leaves, and masticated woody debris (Kane et al. 2010), and scorched needles on the surface of the burned soil may also provide mechanical protection for seeds by restricting secondary movement (Bonnet et al. 2005). Burned areas provide a general increase in soil nutrients such as mineralizable nitrogen and provide opened habitats with less herbaceous competition (Bonnet 2005). Most areas that burned at high severity in the Ute Park Fire still had some intact litter and duff on the soil surface, which may provide suitable conditions for germination if the seed source is accessible.

In areas larger than the effective seeding distance of ponderosa pine (approximately 1 to 1.5 times the parent tree height), previous studies have shown natural tree regeneration to be rare, and it is likely that persistent shrub and grasslands may develop (Lentile et al. 2005). In studies where regeneration of ponderosa pine has occurred, regeneration densities were lower farther from forest edges. Some landowners within the Ute Park Fire area may elect to take action where natural regeneration will not meet their long term forest management objectives. In such cases replanting in select locations with favorable planting sites may be appropriate. Focus should be on large homogenous patches of high severity, in interior portions of the patch that are at the greatest distance from seed sources in unburned seed areas. The New Mexico State Forestry Conservation Seedling Program provides assistance for post fire reforestation through the sale of low cost seedlings to landowners and guidelines for planting and maintenance of seedlings. Seedlings are available for several species (including ponderosa pine and Douglas-fir), in small and large containers and bare root. Information and tools for successful plantings are provided by the Program (New Mexico State Forestry 2018).[13]

Large areas of the Ute Park burn scar that burned at high or moderate severity and lack any surviving seed trees within 500 feet should be targeted for seeding or planting with ponderosa pine, or pinyon pine, depending on which species dominated the location prior to the fire. The New Mexico Forest Practices Guidelines (Paul 2002) provides information on reforestation following fire, both for seeding and planting of containerized seedlings. For complete reforestation, tree seedlings should be planted at a density of 400 to 900 trees per deforested acre, depending on the size of the seedlings. Given the rough terrain of the Ute Park burn, hand planting will probably be required rather than machine planting. Alternatively, tree seedlings could be planted in patches within large high- and moderate-severity burn areas of 10 acres or greater that lack any live mature seed trees. Patch planting will not reforest the area within 10 years, but will produce seed trees that will eventually produce seeds to promote reforestation over 20–50 years.

[13] Conservation Seedling Program – Planting: http://www.emnrd.state.nm.us/SFD/treepublic/Planting.html

Planted seedlings generally have higher survival than individual seeds, but are more costly to obtain and plant. Patch planting will greatly reduce costs, and more attention may be focused on best micro-site placement of seedlings for increased survival success. In addition to patch planting seedlings in large high-severity burn scars, seeding also may be employed on larger portions of the large burn scars over 10 acres in size. Seeding success is generally low, but should still add additional seedlings and ultimately seed trees on larger burn scars in 30–50 years. Contact the New Mexico State Forestry Conservation Seedling Program for details and prices. As with vegetation rehabilitation/restoration, monitoring of seeding or seedling success should be monitored for a period of 1–5 years to evaluate success, as discussed below.

Vegetation Restoration Effectiveness Monitoring

Post-rehabilitation/restoration vegetation seedings/plantings should be monitored for at least 3 to 5 years following treatments. Monitoring will determine whether or not the vegetation plantings were successful, and if not, how they need to be augmented to fulfill their intended purposes. Rehabilitation/restoration effectiveness monitoring should include: 1) specific rehabilitation/restoration treatment objectives defined prior to the treatments and the monitoring being implemented, identifying the characteristics of the vegetation that should be measured/photographed for monitoring, 2) treatment success criteria should be defined before monitoring has begun and based on the original objectives of the treatments, stating what conditions are required in order to consider the vegetation treatments successful or not, 3) baseline measurements or photographs of rehabilitation/restoration sites prior to seeding treatments to document the initial post-fire vegetation and soils conditions, 4) measurements or photographs each year during the late summer to document the status of vegetation recovery and seeding success; and 5) tentative plans to augment or enhance the original treatments if monitoring demonstrates that the treatments are not successful.

Post-treatment vegetation monitoring should at a minimum consist of repeat photo points from permanently located positions or points with views of treatment areas. Interpretation and analysis of time series of repeat photo points may be used to document change in vegetation over time. Repeat photo point monitoring can be qualitative, or designed as rapid assessment, scoring the characteristics of vegetation and soil features on a scale of 1–2, 1–3, 1–5, etc. based on the condition of vegetation, including total canopy cover, foliage heights, species diversity, native vs. non-native, etc. Simple quantitative measurements such as line-point-intercept, with 30 points at 1-m intervals on 30-m transect lines is a quick and easy way to obtain quantitative data on plant species composition and relative canopy cover by species. Ideally, a combination of repeat photo points and simple line-point-intercept measurements are relatively inexpensive and effective ways to monitor the effectiveness of vegetation treatments. See Appendix A for more information on vegetation monitoring.

TRANSPORTATION SYSTEM

U.S. Highway 64

U.S. Highway 64 is the main artery between Cimarron and Eagle Nest, via Ute Park. The Highway is a popular route for tourists detouring from Interstate 25 to visit Eagle Nest and Angel Fire, via Cimarron. According to New Mexico Department of Transportation (NMDOT) data, U.S. Highway 64 is used primarily by cars, pickups, motorcycles and RVs, with very little commercial truck traffic. The Ute Park Fire impacted 8 miles of U.S. Highway 64.

The combined factors of severely burned watersheds adjacent to and above the highway, large volumes of loose stored sediment in channels and on steep slopes, moderate and high burn severity with water repellency, and the location of the floodplain directly below those watersheds and surrounding the highway, indicate a high risk to life and property creating an emergency situation. Motor vehicles and other travelers are at a high risk from debris flows, rock falls, and flooding along the highway within the burn perimeter as well as downstream of the burn perimeter. Secondary fire effects, including post-fire flooding, rock falls, and debris flows, have already created significant impacts to the highway, which has necessitated the County Emergency Management to implement closures during and after some afternoon monsoon rain events. Some large debris has been loosened upslope of U.S. Highway 64, which is raising concern for public safety. NMDOT has installed road signage warning travelers they are entering a burned area as well as concrete wall barriers along vulnerable stretches of highway to retain sediment and prevent it from entering the roadway; however, removal of sediment from behind the barriers needs to occur frequently to ensure they remain effective and do not breach during extreme rain events. U.S. Highway 64 has some portions where blind curves exist; the breach or displacement of these barriers could pose considerable risk to travelers as well as downstream infrastructure if they were mobilized in a debris flow.

County and Private Roads

There are 52 miles of County and Private roads within the burn perimeter. These roads are of varying condition and a full appraisal is not possible due to access issues within the burn scar. Private gravel roads within the burned area are also likely to exacerbate the risk of flooding and erosion by collecting surface water, concentrating it and delivering it to hillslopes or stream channels. Most of the private roads within the burn have inadequate cross-drainage culverts.

County roads within the community of Ute Park have been severely impacted by post-fire flooding and debris flows, particularly during the rain event that impacted the community on June 13–14, 2018 (Figure 3.63 through Figure 3.66). The County Emergency Manager has been working with NMDOT to remove sediment and debris from roads to allow residents to access their homes. Culverts are undersized for the anticipated flow increases, and culvert size will need to be increased or culverts will need to be removed, and replaced after peak flows recover toward pre-burn conditions. Some roads may need to be closed until watershed conditions recover.

Many of the roads observed on Philmont Scout Ranch have been heavily impacted by secondary fire effects of post-fire flooding and debris flows. Some roads are impassable (see Figure 3.65). Some bridges were heavily damaged during the fire (see Figure 3.66) and/or are threatened by post-fire debris flows.

Many of the rehabilitation measures described in the sections above will serve to reduce the risk of flooding and sediment flows that would adversely impact these transportation systems and threaten the health and safety of motorists and residents.

Figure 3.63. Large rocks and debris deposited along Hummingbird Lane in Ute Park.

Figure 3.64. Ute Park post flooding, June 13, 2018, showing debris flow crossing two roads within the community.

Figure 3.65. Post-fire flooding and sediment flow impacts to road surface in Philmont Scout Ranch.

Figure 3.66. Burned-out bridge on Philmont Scout Ranch.

LITERATURE CITED

ARC. 2015. Colfax County Comprehensive Plan 2015: Colfax County Comprehensive Plan. Available at: http://www.co.colfax.nm.us/About%20Colfax%20County/Colfax%20County%202015%20Comprehensive%20Plan.pdf.

Benavides-Solorio, J., L.H. MacDonald. 2001. Post-fire runoff and erosion from simulated rainfall on small plots, Colorado Front Range. Hydrological Processes 15(15):2931–2952.

Bonnet, V.H., A.W. Schoettle, and W.D. Shepperd. 2005. Postfire environmental conditions influence the spatial pattern of regeneration for *Pinus ponderosa*. *Can. J. For. Res.* 35:37–47.

Calkin et al. 2007. Assessing Post-Fire Values-at-risk with a New calculation Tool. https://www.fws.gov/fire/downloads/ES_BAR/Assessing_Post-Fire_values-at-Risk_With_New_Calculation_To.pdf.

Chambers, M.E., P.J. Fornwalt, S.L Malone, and M.A. Battaglia. 2016. Patterns of conifer regeneration following high severity wildfire in ponderosa pine – dominated forests of the Colorado Front Range. *Forest Ecology and Management* 378:57–67.

Cikoski, C.T., and D.J. Koning. 2017. Deep-Seated Landslide Susceptibility Map of New Mexico. New Mexico Bureau of Geology and Mineral Resources Open-File Report OFR-594. Available at: https://geoinfo.nmt.edu/publications/openfile/downloads/500-599/594/OFR-594.pdf.

Cimarron Watershed Alliance (CWA). 2008. Community Wildfire Protection Plan (CWPP). Available at: http://www.emnrd.state.nm.us/SFD/FireMgt/documents/CWPPCimarronWatershed.pdf.

———. 2013. Ponil Creek Restoration Project, Final Report. Available at: https://static1.squarespace.com/static/51ca5c70e4b043b66a223790/t/51ca63bde4b014f2c6e1627b/1372218301402/Ponil319-+Final+Report-FINAL.pdf. Accessed July 31, 2018.

Colfax County. 2008. Colfax County Community Wildfire Protection Plan (CWPP): Available at: http://www.emnrd.state.nm.us/SFD/FireMgt/documents/ColfaxCountyCWPP.pdf.

———. 2016. Colfax Regional Water Plan. Available at: (http://www.ose.state.nm.us/Planning/RWP/Regions/09_Colfax/2016/Reg%209_Colfax_Regional%20Water%20Plan%202016_July%202016.pdf.)

Cottingham, R. 2005, Treatment techniques for wildfire affected drinking water supplies: Big Sky Clearwater, Montana Department of Environmental Quality, v. XXXV, 2(Fall 2005):21–22.

Dean, A.E. 2001. Evaluating effectiveness of watershed conservation treatments applied after the Cerro Grande Fire, Los Alamos, New Mexico. Tucson, Arizona: University of Arizona. Thesis.

DeBano, L.F., D.G. Neary, and P.F. Ffolliott. 1998. Fire's effects on ecosystems. John Wiley & Sons, New York, New York.

DeBano, L.F. 2000. The role of fire and soil heating on water repellency in wildland environments: a review. *Journal of Hydrology* 231:195–206.

Dick-Peddie, W.A. 1993. New Mexico vegetation: Past, present and future. Albuquerque, New Mexico: University of New Mexico Press.

Elzinga, C.L., D.W. Salzer, and J.W. Willoughby. 1998. Measuring and Monitoring Plant Populations. USDI Bureau of Land Management Technical Reference 1730-1. National Business Center, Denver, Colorado. Available at: http://www.blm.gov/nstc/library/pdf/MeasAndMon.pdf.

EMNRD. 2006. Colfax County Community Wildfire Protection Plan (CWPP). Available at: http://www.emnrd.state.nm.us/SFD/FireMgt/documents/ColfaxCountyCWPP.pdf.

———. 2010. Cimarron Canyon State Park Management Plan. Available at: http://www.emnrd.state.nm.us/SPD/documents/CimarronPMPFinalPDFs_001.pdf.

———. 2017. New Mexico Forest Health Conditions. Available at: http://www.emnrd.state.nm.us/SFD/FWHPlan/documents/NMForestHealthConditionsReportComplete.pdf.

————. 2017. Resources for Private Forest Landowners in New Mexico: Available at: http://www.emnrd.state.nm.us/SFD/Publications/documents/ResourcesforPrivateForestLandowners2017_Updated171207.pdf.

Ffolliott, P.F., G.J. Gottfried, and C.L. Stropki. 2011. Fire effects on tree overstories in the oak savannas of the Southwestern Borderlands Region. Res. Pap. RMRS-RP-86. Fort Collins, Colorado: U.S. Department of Agriculture. Forest Service, Rocky Mountain Research Station.

Fire Science 2001. Fire Regimes. Available at: https://www.firescience.gov/projects/09-2-01-9/supdocs/09-2-01-9_Chapter_3_Fire_Regimes.pdf.

Hallema W.D., G. Sun, P.V. Caldwell, S.P. Norman, C.E. Cohen, L.Y. Yongqiang, J.E. Ward, G.S. McNulty. Assessment of Wildland Fire Impacts on Watershed Annual Water Yield: Analytical Framework and Case Studies in the Unites States. Wiley. DOI 10.1002/eco.1794. September 2016.

Harr, R.D. 1976, *Forest Practices and Streamflow in Western Oregon*, U.S. Forest Service, Pacific Northwest Forest and Range Experimental Station, GTR-PNW-49.

Hayes. J.J., and S.M. Robeson. 2011. Relationships between fire severity and post-fire landscape pattern following a large mixed-severity fire in the Valle Vidal, New Mexico, USA. Forest Ecology and Management 26 (2011)1392–1440. http://climate.indiana.edu/RobesonPubs/hayes_robeson_foreco_2011.pdf.

Herrick, J.E., J.W. Van Zee, K.M. Havstad, L.M. Burkett, W.G. Whitford. 2005. Monitoring Manual for Grassland, Shrubland, and Savanna Ecosystems. Volume 1: Quick Start. USDA-ARS Jornada Experimental Range. Las Cruces, New Mexico. http://usda-ars.nmsu.edu/Monit_Assess/PDF_files/Quick_Start.pdf.

Hibbs, D., and R. Jacobs. 2011. Vegetation recovery after fire in the Klamath-Siskiyou region, southern Oregon: U.S. Geological Survey Fact Sheet 2011-3140.

Hilton, J. 2012. Cimarron watershed-based plan. Prepared in cooperation with the Cimarron Watershed Alliance and the Quivira Coalition. December 2012. Available at: https://static1.squarespace.com/static/51ca5c70e4b043b66a223790/t/533dc842e4b0485943bb53aa/1396557890848/2012-12+CWA+WPB+final.pdf.

Idaho State University Rehabilitation Capability Convergence for Ecosystem Recovery Program (RECOVER). 2018. RECOVER Program: Available at: http://giscenter.isu.edu/research/Techpg/nasa_RECOVER/index.htm.

Interagency Burned Area Emergency Response (BAER) Handbook. 2006. Available at: https://www.nps.gov/archeology/npsGuide/fire/docs/18%20Interagency%20BAER%20Handbook.pdf.

Interagency Collaboration. 2006. After Wildfire: A Guide for New Mexico Communities: http://www.emnrd.state.nm.us/SFD/Publications/documents/AfterWildfireguide.pdf.

Interagency Technical Reference. 1999. Sampling Vegetation Attributes. BLM Technical Reference 1734-4. National Business Center, Denver, Colorado. Available at: http://www.blm.gov/nstc/library/pdf/samplveg.pdf.

Jarrett, B. 2009. Typical Front Range Post-Fire Flooding and Flood Hazards for Emergency Managers. Paleohydrology and Climate Change Project U.S. Geological Survey, Denver, Colorado. Available at: https://www.udfcd.org/FWP/F2P2_Reports/FMCfire/USGS/Front%20Range%20Colorado%20Wildland%20Fire%20Flooding.pdf.

Kane, J.M., E.E. Knapp, R.F. Powers, and J.M. Varner. 2010. Understory vegetation response to mechanical mastication and other fuel treatments in a ponderosa pine forest. *Appl. Veg. Sci.* 13:207−220.

Keeley, J.E. 2009. Fire intensity, fire severity and burn severity: a brief review and suggested usage. *International Journal of Wildland Fire* 18:116−126. Available at: https://www.fs.fed.us/postfirevegcondition/documents/publications/keeley_ijwf_2009.pdf.

Key, C.H., and N.C. Benson. 2006. Landscape assessment: Sampling and analysis methods: FIREMON: Fire effects monitoring and inventory system. General Technical Report. U.S. Forest Service, Rocky Mountain Research Station, Fort Collins CO., RMRS-GTR-164-CD. https://www.fs.fed.us/rm/pubs/rmrs_gtr164/rmrs_gtr164_13_land_assess.pdf

Landsberg, J.D., and A.R. Tiedemann. 2000. Fire management, in Dissmeyer, G.E., ed., Drinking water from forests and grasslands—A synthesis of the scientific literature: U.S. Department of Agriculture Forest Service General Technical Report SRS–39, p. 124–138.

Lentile, L.B., F.W. Smith, and W.D. Shepperd. 2005. Patch structure, fire-scar formation, and tree regeneration in a large mixed-severity fire in the South Dakota Black Hills, USA. *Can. J. For. Res.* 35:2875–2885.

Leopold, L.B., M.G. Wolman, and J.P. Miller. 1964. "Fluvial processes in geomorphology," W. H. Freeman and Company, San Francisco, California.

Lutes, D.C., R.E. Keane, J.F. Caratti, C.H. Key, N.C. Benson, S. Sutherland, L.J. Gangi. 2006. FIREMON: Fire Effects Monitoring and Inventory System. Gen. Tech. Rep. RMRS-GTR-164-CD. For Collins, Colorado: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 1 CD. 400p. http://www.treesearch.fs.fed.us/pubs/24042

MacDonald, L., and I. Larsen 2009 Effects of Forest Fires and Post Fire Rehabilitation: A Colorado, USA Case Study. In Fire Effects on Soils and Restoration Strategies. Edited: A. Cerda, and P. Robichaud. Volume 5 Series: Land Reconstruction and Management. Oxford Brookes University, Oxford, UK. Available at: https://www.fs.fed.us/psw/publications/4403/nonfs/mcdonald.2009.FireEffectsonSoilsandRestorationStrategies.EffectsForestFires.pdf.

Meixner, T. 2004. Wildfire Impacts on Water Quality. Southwest Hydrology, Feature 7. Available at: http://www.swhydro.arizona.edu/archive/V3_N5/feature7.pdf.

Moody, J.A. 2001. Sediment transport regimes after a wildfire in steep mountainous terrain, in Proceedings of the Seventh Federal Interagency Sedimentation Conference, March 25–29, 2001, Reno, Nevada: U.S. Subcommittee on Sedimentation, A Subcommittee of the Advisory committee on Water Information (ACWI), chap. 10, p. X-41–X-48.

Moody, J.A., and Martin, D.A., 2001, Initial hydrologic and geomorphic response following a wildfire in the Colorado Front Range: *Earth Surface Processes and Landforms*, v. 26, p.1049–1070.

Napper. 2006. Burned Area Emergency Response (BAER) Treatments Catalog. Available at: http://www.fs.fed.us/eng/pubs/pdf/BAERCAT/lo_res/06251801L.pdf.

National Park Service. 2003. Fire Monitoring Handbook: Fire Management program Center, National Interagency Fire Center. Boise, ID. 274 p. Available at: http://www.nps.gov/fire/fire/fir_eco_mon_fmh.cfm.

Natural Resources Conservation Service (NRCS). NRCS Engineering Division. Urban Hydrology for Small Watersheds. Technical Release 55, TR-55. June 1986.

———. Soil Web Surveys for Colfax County, New Mexico. Accessed July 28, 2018.

Neary, D.G., K.C. Ryan, and L.F. DeBano (eds.). 2005. Revised 2008. Wildland fire in ecosystems: effects of fire on soils and water. Gen. Tech. Rep. RMRS-GTR-42-vol. 4. Odgen, UT: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 250 p.New Mexico Department of Agriculture, 2016. New Mexico Noxious Weed List. Available at: http://www.nmda.nmsu.edu/wp-content/uploads/2016/11/Weed-List-memo-and-weed-list-2016.pdf.

New Mexico State Forestry. 2008. Forest Practices Guideline: Available at: http://www.emnrd.state.nm.us/SFD/Publications/documents/NM_ForestPracticesGuidelines2008.pdf.

———. 2018. Conservation Seedling Program- Available at: http://www.emnrd.state.nm.us/SFD/treepublic/Planting.html

National Wildfire Coordinating Group. 2006. Fire Regime Groups: Available at: https://www.nwcg.gov/term/glossary/fire-regime-groups%C2%A0.

Ouzts, J., T. Kolb, D. Huffman, and A. Sánchez Meador. 2015. Post-fire ponderosa pine regeneration with and without planting in Arizona and New Mexico. *Forest Ecology and Management*, *354*, 281–290. DOI: 10.1016/j.foreco.2015.06.001.

Page-Dumroese, D., D. Neary, and C. Trettin. 2010. Scientific background for soil monitoring on National Forests and Rangelands: workshop proceedings; April 29-30, 2008; Denver, CO. Proc. RMRS-P-59. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5294523.pdf.

Paul, K. 2002. New Mexico Forest Practices Guidelines, 2002 edition. New Mexico Energy, Minerals and Natural Resources, Forestry Division. Santa Fe, New Mexico.

Rhoades, C., D. Entwistle, and D. Butler. 2006. Initial streamwater response to the Hayman Fire, Colorado Front Range, in Fowler, D.L., compiler, Second Interagency Conference on Research in the Watersheds—Challenges and opportunities for watershed research, May 16–18, 2006, Coweeta Hydrologic Laboratory, Otto, North Carolina, Proceedings: U.S. Department of Agriculture, Agricultural Research Service, pp. 89–98.

Rhoades, C.C., D. Entwistle, and D. Butler. 2011. The influence of wildfire extent and severity on streamwater chemistry, sediment and temperature following the Hayman fire, Colorado: International Journal of Wildland Fire, v. 20, p. 430–442.

Robichaud, P.R. 2000. Fire effects on infiltration rates after prescribed fire in Northern Rocky Mountain forests, USA. *Journal of Hydrology* 231:220–229.

Robichaud, P.R. 2000. Forest fire effects on hillslope erosion: what we know. Watershed Management Council Networker 9(1): Winter 2000. Available at: http://watershed.org/news/win_00/2_hillslope_fire.htm.

Robichaud, P.R., J.L. Beyers, and D.G. Neary. 2000. Evaluating the effectiveness of post-fire rehabilitation treatments. USDA Forest Service, Rocky Mountain Research Station, General Technical Report RMRS-GTR-63. Available at: http://www.fs.fed.us/rm/pubs/rmrs_gtr63.pdf.

Robichaud P., J.W. Elliot, E.D. Hall, A.C. Moffet, L.E. Ashman. 2006. Erosion Risk Management Tool (ERMiT) User Manual version 2006.01.18. U.S. Department of Agriculture Forest Service Rocky Mountain Research Station General Technical Report RMRS-GTR-188. April 2007.

Robichaud, P., T.R. Lillybridge, and J. Wagenbrenner. 2006. Effects of postfire seeding and fertilizing on hillslope erosion in north-central Washington, USA. CATENA. 67. 56-67. 10.1016/j.catena.2006.03.001.

Robichaud, P, F. Pierson, R.E. Brown, and J. Wagenbrenner. 2008. Measuring effectiveness of three postfire hillslope erosion barrier treatments, western Montana, USA. Hydrological Processes. 22. 10.1002/hyp.6558.

Robichaud, P., J. Wagenbrenner, R.E. Brown, and K.M. Spigel. 2009. Three Years of Hillslope Sediment Yields Following the Valley Complex Fires, Western Montana.

Robichaud, P.R., L.E. Ashmun, and B.D. Sims. 2010. Post-fire treatment effectiveness for hillslope stabilization. Gen. Tech. Rep. RMRS-GTR-240. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 62 p. https://www.firescience.gov/projects/08-2-1-10/project/08-2-1-10_rmrs_gtr240.pdf.

Rosgen, D.L. 2001. A Hierarchical River Stability/Watershed-Based Sediment Assessment Methodology In *Proceedings of the Seventh Federal Interagency Sedimentation Conference: Vol. 1.* (pp.II-97–II-106). Reno, NV: Subcommittee on Sedimentation.

———. 2006. Watershed Assessment of River Stability and Sediment Supply. 2nd Edition. Wildland Hydrology.

———. 2007. Rosgen Geomorphic Channel Design. Chapter 11, Part 654 Stream Restoration Design. National Engineering Handbook. NRCS.

———. 2009. *Journal of the American Water Resources Association, 45*(5), 1290−1297. The definitive version is available at www.blackwell-synergy.com

———. 2011. In A. Simon, S.J. Bennett, & J.M. Castro (Eds.), *Stream Restoration in Dynamic Fluvial Systems: Scientific Approaches, Analyses, and Tools*, Geophysical Monograph Series 194, pp. 69–93. Washington, D.C.: American Geophysical Union.

———. 2014. River Stability Field Guide. 2nd Edition. Wildland Hydrology.

Satterfield, Z. 2006a. Taste and odor control: National Environmental Services Center at West Virginia University, National Drinking Water Clearinghouse Fact Sheet, Tech Brief, v. 6, no. 1.

———. 2006b. Turbidity control: National Environmental Services Center at West Virginia University, National Drinking Water Clearinghouse Fact Sheet, Tech Brief, v. 6, no. 2, 4 p.

Schoeneberger, P.J., D.A. Wysocki, and E.C. Benham. 1998. Field book for describing and sampling soils. Lincoln, NE: U.S. Department of Agriculture, Natural Resources Conservation Service, National Soil Survey Center.

Scott, J.H., and R.E. Burgan. 2005. Standard fire behavior fuel models: a comprehensive set for use with Rothermel's surface fire spread model. Gen. Tech. Rep. RMRS-GTR-153. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 72 p.

Southwest Regional Gap Analysis Project (SWReGAP). 2018. Available at: http://swregap.nmsu.edu/HMdatabase/landc_database_report.pdf.

Stednick, J.D., and T.J. Kern, T.J. 1992. 'Long-Term Effects of Timber Harvesting in the Oregon Coast Range: The New Alsea Watershed Study (NAWS)', in: *Inter-Disciplinary Approaches in Hydrology and Hydrogeology*, American Institute of Hydrology, pp. 502–510.

Stednick, J.D. 1996. Monitoring the effects of timber harvest on annual water yield. Journal of Hydrology 176: 79-95.Stevens, M.R., 2013, Analysis of postfire hydrology, water quality, and sediment transport for selected streams in areas of the 2002 Hayman and Hinman fires, Colorado: U.S. Geological Survey Scientific Investigations Report 2012–5267, 93 p., http://dx.doi.org/10.3133/sir20125267.

University of New Mexico Water Resources Program. 2010. Water Resources Assessment of the Cimarron River and Evaluation of Water Quality Characteristics at the Maxwell National Wildlife Refuge, Dr. Bruce Thomson and Dr. Abdul-Mehdi Ali, editors.

U.S. Census 2010. Colfax County, Quick Facts. Available at: https://www.census.gov/quickfacts/fact/table/colfaxcountynewmexico,cimarronhillscdpcolorado,cimarroncountyoklahoma,unioncountynewmexico,US/POP010210.

U.S. Fish and Wildlife Service. 1999. Fuel and Fire Effects Monitoring Guide. Available at: http://www.fws.gov/fire/downloads/monitor.pdf.

U.S. Forest Service. 2017. Burned Area Reflectance Classification: Available at: https://www.fs.fed.us/eng/rsac/baer/barc.html.

———. 2017. Forest Service Manual 2500- Watershed Protection and Management- Interim Directive No. 2520-2017-1. https://www.fs.fed.us/dirindexhome/fsm/2500/wo_id_2520-2017-1.doc.

———. 2009. Forest Soil Disturbance Monitoring Protocol. Volume I. Rapid Assessment. https://forest.moscowfsl.wsu.edu/smp/solo/documents/GTRs/WO_82/SoilMonProtocol_GTR-WO-82a.pdf.

———. 2010. Field Guide for Mapping Post-Fire Soil Burn Severity. General Technical Report RMRS-GTR-243. https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5294524.pdf.

U.S. Geological Survey 2012. Wildfire Effects on Source Water Quality- Lessons from the Fourmile Canyon Fire, Colorado, and Implications for Drinking-Water Treatment. Fact Sheet 2012-3095. July 2012. Available at: https://pubs.usgs.gov/fs/2012/3095/FS12-3095.pdf.

Volk, C., L.A. Kaplan, J. Robinson, B. Johnson, L. Wood, H.W. Zhu, and M. Lechevallier. 2005. Fluctuations of dissolved organic matter in river used for drinking water and impacts on conventional treatment plant performance: Environmental Science and Technology, v. 39, p. 4258–4264.

Wagenbrenner W.J., and P.R. Robichaud. Post-fire bedload sediment delivery across special scales in the Interior western United States. Earth Surface Processes and Landforms 39, 865-876. September 2013.

Wildland Fire Assessment. 2018. Dead fuel moisture classes: https://www.wfas.net/index.php/dead-fuel-moisture-moisture--drought-38.

Wirth, T.A., and D.A. Pyke. 2007. Monitoring post-fire vegetation rehabilitation projects—A common approach for non-forested ecosystems: U.S. Geological Survey Scientific Investigations Report 2006-5048, 36 p.: https://pubs.usgs.gov/sir/2006/5048/pdf/sir20065048.pdf.

U.S. Army Corps of Engineers (USACE). Memorandum for Record: Critical Infrastructure Hazard Assessment Following the Ute Park Wildfire near Cimarron, New Mexico. USACE CESPA-PM-LH (CIWHU). June 30, 2018.

APPENDIX A – MONITORING RECOMMENDATIONS

The following information was taken from several publications that examine the effectiveness of post fire rehabilitation treatments (Robichaud et al. 2000; Wirth and Pyke 2007) The following excerpts are taken from the Interagency BAER Guidebook (2006):[14]

> *"Monitoring and evaluation of post-fire treatments are critical for understanding and improving such treatments. The objective of treatment effectiveness is to determine if plan objectives were met. Effectiveness monitoring is used to evaluate whether the installed treatment had the desired effect. This information is used to adapt management treatments and activities for the current and future projects to increase effectiveness."*

> *"Monitoring intensity should be commensurate with the complexity of the emergency stabilization treatments and the level of concern or controversy associated with the emergency stabilization treatment. The effectiveness monitoring specification should document the specific monitoring objective for that project, the monitoring protocol, personnel/equipment needed, and the funding needs."*

Intensive Monitoring Approaches

Intensive quantitative monitoring uses research-derived, multi-metric indices to give detailed information about how a resource is changing relative to a rehabilitation action. If an intensive monitoring protocol is deemed necessary, a number of different approaches can be taken, as described below. A good first step when designing a monitoring protocol for post-fire rehabilitation treatments is to review the BAER Catalog.[15] Each treatment option in the catalog includes treatment monitoring recommendations that could guide the monitoring approach.

Vegetation Monitoring Protocols

There are several vegetation monitoring protocols developed by federal agencies to support post fire rehabilitation work and treatment effectiveness for vegetation. These methods vary in their objectivity and repeatability. The most repeatable methods are point-intercept, quadrat-based density measurements, gap intercepts, and direct measurement of soil erosion (Wirth et al. 2007). Common protocols that could be applied in the Ute Park Burn area are listed below in Table A.1.

Table A.1. Vegetation Monitoring Manuals Suitable for Use in Monitoring of Ute Park Fire Vegetation Rehabilitation and Restoration Measures

Manual/Scientific Paper	Citation
Measuring and Monitoring Plant Populations	Elzinga, C.L., Salzer, D.W., and Willoughby, J.W., 1998. Measuring and Monitoring Plant Populations. USDI Bureau of Land Management Technical Reference 1730-1. National Business Center, Denver, CO. 492p. http://www.blm.gov/nstc/library/pdf/MeasAndMon.pdf
Sampling Vegetation Attributes	Interagency Technical Reference, 1999. Sampling Vegetation Attributes. BLM Technical Reference 1734-4. National Business Center, Denver, CO. 158 p. http://www.blm.gov/nstc/library/pdf/samplveg.pdf
Fire Monitoring Handbook	USDI National Park Service, 2003. Fire Monitoring Handbook: Fire Management program Center, National Interagency Fire Center. Boise, ID. 274 p. http://www.nps.gov/fire/fire/fir_eco_mon_fmh.cfm

[14] Interagency BAER Guidebook. 2006: https://www.nps.gov/archeology/npsGuide/fire/docs/18%20Interagency%20BAER%20Handbook.pdf

[15] BAER Catalog: https://www.fs.fed.us/t-d/pubs/pdf/BAERCAT/lo_res/06251801L.pdf

Manual/Scientific Paper	Citation
Monitoring Manual for Grassland, Shrubland, and Savannah Ecosystems	Herrick, J.E., Van Zee, J.W., Havstad, K.M., Burkett, L.M., Whitford, W.G., 2005a. Monitoring Manual for Grassland, Shrubland, and Savanna Ecosystems. Volume 1: Quick Start. USDA-ARS Jornada Experimental Range. Las Cruces, NM. 36 p. http://usda-ars.nmsu.edu/Monit_Assess/PDF_files/Quick_Start.pdf
Fire Effects Monitoring and Inventory Protocol (FIREMON)	Lutes, Duncan C., Keane, Robert, E., Caratti, John. F., Key, Carl H., Benson, Nathan C., Sutherland, Steve, Gangi, Larry J., 2006. FIREMON: Fire Effects Monitoring and Inventory System. Gen. Tech. Rep. RMRS-GTR-164-CD. For Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 1 CD. 400p. http://www.treesearch.fs.fed.us/pubs/24042
Fuel and Fire Effects Monitoring Guide	USDI Fish and Wildlife Service, 1999. Fuel and Fire Effects Monitoring Guide. http://www.fws.gov/fire/downloads/monitor.pdf

Source: Wirth et al. (2007)

Soil Monitoring Protocols

There are several soil monitoring protocols developed by federal agencies to support post fire rehabilitation work. It is important to monitor soils following disturbance for physical attributes that could influence site resilience and long-term sustainability. The attributes describe surface conditions that affect site sustainability and hydrologic function. Monitoring the attributes of surface cover, ruts, compaction, burn severity and platy structure can also be used to generate best management practices that help maintain site productivity (U.S. Forest Service 2009).[16] Common protocols that could be applied in the Ute Park burn area are listed below in Table A.2.

Table A.2. Soil Monitoring Manuals Suitable for Use in Monitoring of Ute Park Fire Soil Rehabilitation and Restoration Measures

Manual/Scientific Paper	Citation
USDA Forest Service, 2009. Forest Soil Disturbance Monitoring Protocol.	USDA Forest Service, 2009. Forest Soil Disturbance Monitoring Protocol. Volume I. Rapid Assessment. https://forest.moscowfsl.wsu.edu/smp/solo/documents/GTRs/WO_82/SoilMonProtocol_GTR-WO-82a.pdf USDA Forest Service, 2009. Forest Soil Disturbance Monitoring Protocol. Volume II: Supplementary Methods, Statistics, and Data Collection. https://www.fs.fed.us/rm/pubs_series/wo/wo_gtr082b.pdf
Field book for describing and sampling soils.	Schoeneberger, P.J.; Wysocki, D.A.; Benham, E.C., et al. 1998. Field book for describing and sampling soils. Lincoln, NE: U.S. Department of Agriculture, Natural Resources Conservation Service, National Soil Survey Center.
USDA Forest Service, 2010. Field Guide for Mapping Post-Fire Soil Burn Severity.	USDA Forest Service, 2010. Field Guide for Mapping Post-Fire Soil Burn Severity. General Technical Report RMRS-GTR-243. https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5294524.pdf
Scientific Background for Soil Monitoring on National Forests and Rangelands. 2008.	Page-Dumroese, Deborah; Neary, Daniel; Trettin, Carl, tech. eds. 2010. Scientific background for soil monitoring on National Forests and Rangelands: workshop proceedings; April 29-30, 2008; Denver, CO. Proc. RMRS-P-59. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 126 p. https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5294523.pdf
Several soil publications	https://www.fs.usda.gov/detail/r8/landmanagement/resourcemanagement/?cid=stelprdb5293546

[16] USDA Forest Service 2009. https://forest.moscowfsl.wsu.edu/smp/solo/documents/GTRs/WO_82/SoilMonProtocol_GTR-WO-82a.pdf

Hydrological Monitoring Protocols

Hydrological monitoring typically focuses on measuring rainfall totals, runoff, peak flows, sediment yields and change in channel shape morphology over time in order to evaluate the effectiveness of rehabilitation treatments. Measurements of treatment effectiveness are most useful when they are directly related to the objective(s) of the treatment. For example, if a hillslope treatment is applied to reduce runoff and erosion, then the monitoring should measure rainfall characteristics, hillslope runoff, and erosion rates over several years (Robichaud et al. 2010).[17] A large number of monitoring studies have evaluated treatment effectiveness of post fire restoration treatments related to hydrology. A sample of those are included in Table A.3.

Table A.3. Hydrologic Monitoring Manuals and Literature Suitable for Use in Monitoring of Ute Park Fire Hydrological and Geomorphological Rehabilitation and Restoration Measures

Manual/Scientific Paper	Citation
Post-Fire Treatment Effectiveness for Hillslope Stabilization	Robichaud, Peter R.; Ashmun, Louise E.; Sims, Bruce D. 2010. Post-fire treatment effectiveness for hillslope stabilization. Gen. Tech. Rep. RMRS-GTR-240. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 62 p. https://www.firescience.gov/projects/08-2-1-10/project/08-2-1-10_rmrs_gtr240.pdf
Post-Fire runoff and Erosion from simulated rainfall on small plots	Benavides-Solorio, J.; MacDonald, L.H. 2001. Post-fire runoff and erosion from simulated rainfall on small plots, Colorado Front Range. Hydrological Processes 15(15): 2931-2952.
Evaluating the effectiveness of post-fire watershed conservation treatments applied after the Cerro Grande Fire.	Dean, A.E. 2001. Evaluating effectiveness of watershed conservation treatments applied after the Cerro Grande Fire, Los Alamos, New Mexico. Tucson, AZ: University of Arizona. 116 p. Thesis.
BAER CAT- channel treatments section	Burned Area Emergency Response Treatment Catalog. 2006. https://www.fs.fed.us/t-d/pubs/pdf/BAERCAT/lo_res/06251801L.pdf

Qualitative Monitoring

Qualitative monitoring may provide a more cost-effective rapid assessment of conditions following rehabilitation treatments and are the recommended form of monitoring for project implementation.

Repeat Photo Points

Photo monitoring may be used for quantitative measurements of vegetation change by actually measuring vegetation in the photographs. Photo monitoring also has been used for stream and wetland restoration to evaluate changes in riparian geomorphology, as well as vegetation. The value of photo monitoring is that it is easy and inexpensive to take the photographs, and it takes little time or expertise to analyze the photographs. The primary drawback to qualitative photo monitoring is that the analysis of the photographs is somewhat subjective, and interpretation may vary among observers. Any photo monitoring protocol, especially interpretation and analysis, must be standardized and consistent among users in order to be accurate and effective.

[17] Robichaud et al. 2010: https://www.firescience.gov/projects/08-2-1-10/project/08-2-1-10_rmrs_gtr240.pdf

Unlike high-intensity measurement monitoring, photo monitoring is a rapid assessment, qualitative evaluation of change in parameters as observed in repeat photographs over time. Rather than measuring parameter values, visual changes in parameter conditions are scored on a linear scale from low to high. Low to high rank scales are a common way of evaluating and scoring items such as Likert scales used in opinion surveys, and rank scales have been developed for photo monitoring (Garrard et al. 2012). Rank scales cover a range of response values, from negative to neutral to positive, and the scores can be used to evaluate whether an attribute, parameter, or item is trending in a positive, negative, or static direction. Statistics can even be applied to rank scale scores from different people to test for significance differences in score trends among items from a series of photographs representing different photo points (Garrard et al. 2012). A rank scale is used to evaluate environmental change as positive, negative, or static for objectives of each rehabilitation project, for example increased herbaceous vegetation as an objective of a seeding treatment. Environmental parameters that are used as items for the evaluations of repeat photographs must be parameters that can be observed and evaluated in the photographs. The following parameters are suitable for photo monitoring:

- Soils: 1) Erosion and 2) surface stability
    - Soil erosion will appear as bare soil with surface rills, litter dams among bare soil, and rock and twig pedestals. Surface stability can be evaluated by differentiation of loose friable soil surfaces from crusted soil surfaces, and bare soil versus litter or wood chip cover.
    - Indications of high levels of soil erosion involve high levels of runoff.
- Trees and Woody Vegetation: 1) a change in growth and health of remaining trees, and 2) a reduction in vertical (standing) and dead/down (on the ground) wildfire fuels
    - Changes in tree density, vertical structure, and tree health are relatively easy to observe in repeat photographs.
- Herbaceous Vegetation: 1) A change in the canopy cover of herbaceous vegetation, 2) a change in the species composition and diversity of herbaceous vegetation, and 3) a change in the abundance and cover of invasive exotic weed species.
    - Changes in herbaceous vegetation canopy cover and species diversity are relatively easy to observe in repeat photographs. Photographs should be taken near the end of the summer growing season to view the maximum growth of herbaceous vegetation. Some but not all exotic invasive weeds may be observed in photographs.

EVALUATING AND SCORING REPEAT PHOTOS

Environmental change is evaluated by comparing photographs from the same photo point of the same view, taken at different times. In most cases, the photograph taken at the latest date is compared to the original pre-treatment or baseline photograph. However, any pair of photographs may be compared, depending on the need to evaluate change over any particular time period. Repeat photographs are evaluated for environmental change using photo monitoring evaluation forms where each environmental parameter is scored and other information recorded as follows:

1. Soil Erosion and Surface Stability

- +2: Considerable decrease in soil erosion and increased surface stability
- +1: Some decrease in soil erosion and increased surface stability
- 0: No change in soil erosion or surface stability
- -1: Some increased in soil erosion and reduced surface stability

- -2: Considerable increase in soil erosion and reduced surface stability

Comments (*note other changes that are not scored and any uncertainty or questions about scoring*): Status of leaf litter, amount of bare soil surfaces and their appearances, down woody material status, rivulet formation, etc. Leaf litter increase surface stability and reduce erosion potential. Bare soil surfaces generally have lower surface stability and are prone to erosion, especially if surface crusts are lacking.

1. Tree Density and Vertical Wildfire Fuels

- +2: Considerably lower tree density and vertical fire fuels
- +1: Lower tree density and vertical fire fuels
- 0: No change in tree density and vertical fire fuels
- -1: Greater tree density and vertical fire fuels
- -2: Considerably greater tree density and vertical fire fuels

Comments (note other changes that are not scored and any uncertainty or questions about scoring): Change in tree species composition, size classes, etc.

1. Tree and Other Woody Vegetation Growth and Health

- +2: Considerable growth and more healthy trees
- +1: Some increased growth and more healthy trees
- 0: No change in tree growth or health
- -1: Some decreased tree growth and tree health
- -2: Considerable decreased tree growth and health including mortality

Comments (*note other changes that are not scored and any uncertainty or questions about scoring*): Condition by species, descriptive signs of health and growth, identification of insect/disease or other damage.

1. Herbaceous Vegetation

- +2: Considerably greater herbaceous vegetation cover and diversity
- +1: Greater herbaceous vegetation cover
- 0: No change in herbaceous vegetation cover and diversity
- -1: Lower herbaceous vegetation cover and diversity
- -2: Considerably lower herbaceous vegetation cover and diversity

Comments (*note other changes that are not scored and any uncertainty or questions about scoring*): Change in species composition, canopy height, dominant native grasses, any exotic invasive weeds, etc.

1. Other Observable Changes

Comments: Note any other changes not addressed above that may reflect site conditions relative to soils, hydrology, vegetation, and wildlife. Note how livestock grazing may affect visible vegetation cover.

REPEAT PHOTO ANALYSIS

The above scoring is conducted on a Photo Monitoring Restoration Effectiveness Analysis: 2-Photo Comparison photo monitoring data form that is a Microsoft Excel spreadsheet and calculates an overall score for each repeat photo comparison analysis for each treatment site. Multiple photo point photographs and scores for a particular project and time period are then averaged to provide an overall average score by using a Photo Monitoring Restoration Effectiveness Analysis: Multi-Photo Averages form. Finally, a Photo Monitoring Restoration Effectiveness Analysis: Multi-Photo Score Trend form is used to determine score trends over time (for both single photo points and from averaged multiple photo points) and to actually evaluate score trends over time. The same scoring is applied to all photographs taken from any particular treatment site.

ANALYSIS AND INTERPRETATION OF PHOTO MONITORING DATA

The growth and health of vegetation each year depends considerably on weather conditions prior to the dates that photo-point photographs are taken. Analysis of repeat photographs must include considerations for previous weather conditions, especially rainfall, prior to each photograph or series of photographs analyzed. The interpretation of repeat photographs and score trends must include a discussion of weather/climate conditions over the range of time that the photographs represent. The growth and health of vegetation observable in the photographs may be more the result of past weather/climate than the treatment itself.

As with weather, livestock grazing can have significant effects on the cover and height of herbaceous vegetation, the amount of bare soil, and the surface stability and the erosion of soil surfaces. If a site has experienced heavy livestock grazing, this is noted in the comments. In such cases, livestock grazing, like weather, may have a greater impact and observable effect than the treatment alone.

Any other environmental factors or land management/use practices, such as follow-up treatments, brush control, erosion control, etc., that may affect the appearance of soils, trees, and herbaceous vegetation are documented and considered when evaluating repeat photographs for treatment affects.

APPENDIX B – BAER TEAM AND STAKEHOLDERS

Skill Represented on Burned-Area Survey Team

Team Leader/Soil Scientist Contact Information:

Cody Stropki PhD, Watershed Scientist/Fire Ecologist: cstropki@swca.com 505.254.1115

Team Members:

Hydrology:

Crystal Young, P.E., Hydrologist

Engineers:

David Bidelspach, P.E., Project Engineer

Ken Lai, Project Engineer

Forestry/Range:

Kent Reid, Forester, New Mexico Forest and Watershed Restoration Institute

Fish/Wildlife Biologists:

David Lightfoot, PhD Ecologist

Fire Ecologist:

Victoria Amato, Fire Ecologist

GIS Support:

Bryan Swindell, GIS

Dave Barz, GIS

Table B.1. Interested Parties List from Ute Park Fire Watershed Stabilization Coordination

Entity	Jurisdiction	Role	Data/Reports	Contact information
Village of Cimarron	Mayor of Cimarron	Main focus is on water supply for Village of Cimarron and protection of the intakes within Philmont Scout Ranch. All entities are coordinating to maintain primary and secondary water supply for Cimarron, Springer and Raton.	N/A	Leo Martinez 575-376-2232 Leo87714@yahoo.com
Town of Springer/ NMSU Colfax County Extension	Springer		N/A	Boe Lopez Mayor/Extension Agent 505-469-9055 bclopez@nmsu.edu
Springer Ditch Company	Springer	Responsible for control water flow into Springer lake	N/A	Andy Yates 505-604-1251 andyyates40@gmail.com
Cimarron Canyon State Park	NM State Parks	Local state partner.	Useful background materials are available in the Cimarron Canyon State Park Management Plan (2010) http://www.emnrd.state.nm.us/SPD/documents/CimarronPMPFinalPDFs_001.pdf	Steve Clark- Park Ranger 28869 Highway 64 Eagle Nest, NM 87718 575-377-6271 Stephen.Clark@state.nm.us
Cimarron Watershed Alliance (CWA)	Non-profit group working within the Cimarron River Watershed	Available to be a fiscal sponsor for any grant funded projects. Has active membership within the watershed and regularly carry out restoration work in conjunction with other stakeholders.	Cimarron Watershed-Based Plan (2012)[18] Numerous references to watershed studies on pages 11-20, data on water quality etc. on pages 21-27, Management Measures and BMPS summarized by reach in Table 7-1. Specific projects - wildland urban interface projects near town of Cimarron and seeking to generate more defensible space work on the larger land owner communities and around Ute Park.	Rick Smith President 662-312-1678 Rcsmith3@gmail.com Information at: http://cimarronwatershed.com/

[18] Hilton, J. 2012. Cimarron watershed-based plan. Prepared in cooperation with the Cimarron Watershed Alliance and the Quivira Coalition. December 2012. Available at https://static1.squarespace.com/static/51ca5c70e4b043b66a223790/t/533dc842e4b0485943bb53aa/1396557890848/2012-12+CWA+WPB+final.pdf.

Entity	Jurisdiction	Role	Data/Reports	Contact information
Colfax County	Emergency Management	Can act as a fiscal agent for rehabilitation work but cannot provide match funds for projects or maintenance funds. Currently serving as fiscal agent for NRCS activities.	Colfax County Comprehensive Plan (2015): http://www.co.colfax.nm.us/About%20Colfax%20County/Colfax%20County%202015%20Comprehensive%20Plan.pdf Good source of information of baseline conditions within the Count	Thomas Vigil Emergency Manager 230 North 3rd Street P.O. Box 1498 Raton, NM 87740 Phone: (575) 445-7050 Cell: (575) 707-3579 Fax: (575) 445-2902 E-mail: tvigil@co.colfax.nm.us http://www.co.colfax.nm.us/government/emergency_management.php
Colfax County Soil and Water Conservation District (SWCD)	District lands (private)	Can act as a fiscal agent for rehabilitation work but cannot provide matching funds for projects or maintenance funds. Could apply for apply for Water Quality Grant through NM Soil and Water Conservation Commission.	N/A	245 Park Avenue, Suite 206 Raton, NM 87740 (575) 445-9571x5
National Weather Service (NWS)	Federal	Early warning to local communities for post fire flooding. Assist with the placement of rain gages within the burn scar.	Provide summary of rain after events that produce large flood pulses or debris flow.	Royce Fontenot, Senior Service Hydrologist 505-244-9150 royce.fontenot@noaa.gov Kerry Jones, Warning Coordinator Meteorologist kerry.jones@noaa.gov; 505-244-9150

Entity	Jurisdiction	Role	Data/Reports	Contact information
Natural Resource Conservation Service (NRCS)	Private land assistance	NRCS has a private land focus. They are currently implementing the Emergency Watershed Protection Program throughout the burn area (except on Vermejo Park Ranch lands). They are developing engineering plans for: Sediment basins Trash racks Log drop structures Areas for mastication Areas for contour felling Debris removal	Developing Report for mitigation measures. Numerous information sources produced by NRCS: Emergency Watershed Protection Program: https://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/landscape/ewpp/	Kenneth Branch Resource Conservationist State Office: 6200 Jefferson Street N. E. Albuquerque, NM 87114 (505) 761-4454 Kenneth.branch@nm.usda.gov Kristin Graham-Chavez Assistant State Conservationist for Programs Kristin.grahamchavez@nm.usda.gov Local office: USDA Raton 245 PARK AVE RATON, NM 87740-3800 Phone: (575) 445-9571 ext 3 Fax: (855) 538-5999
NM Department of Game and Fish (NMDGF)	State	Conducting restoration on ~200 acres of State lands that were burned during the fire.	NA	Jacob Davidson Habitat Manager 505-476-8112 jacob.davidson@state.nm.us

Entity	Jurisdiction	Role	Data/Reports	Contact information
NM Department of Homeland Security and Emergency Management (NMDHSEM)	State	DHSEM Recovery Unit administers FEMA Fire Management Assistance grants (FMAG), which can be used for reimbursement for fire suppression activities, prepositioning activities, emergency services, and temporary repair of damaged facilities caused by fire suppression. Application is though DHSEM Recovery Unit 30 days after the incident period ends. DHSEM Mitigation Program administers FEMA natural hazard mitigation grants that can be used for watershed stabilization, hazardous fuels reduction, defensible space and flood risk reduction. The Pre-disaster Mitigation Program is an annual grant expected to be open this fall. The FMAG – Post Fire Grant has been awarded to DHSEM for the Ute Park Fire. The Hazard Mitigation Grant Program is made available only with a federal disaster declaration. Application for all FEMA mitigation grants is through DHSEM.	FMAG Guide presentation and needed forms for the reimbursement process are current and available for download at http://www.nmdhsem.org/Resources.aspx State Natural Hazard Mitigation Plan profiles 14 natural hazards including, wildfire, flood and post-wildfire flooding. Up-date will be available for download in October at http://www.nmdhsem.org/Mitigation.aspx	Rosalita M. Whitehair Recovery Unit Manager NMDHSEM Response and Recovery Bureau 505-476-9601 Rosalita.Whitehair@state.nm.us Matthew Smith Recovery Officer NMDHSEM Response and Recovery Bureau 505-469-1556 Matthew.Smith5@state.nm.us Wendy Blackwell State Hazard Mitigation Officer 505-476-9676 Wendy.blackwell@state.nm.us

Entity	Jurisdiction	Role	Data/Reports	Contact information
NM Environment Department (NMED) Drinking Water Bureau Surface Water Quality Bureau	State	Drinking Water Bureau can work with property owners on expedited permitting or exemptions if specific criteria is met. Surface Water Bureau may be able to provide grant funding to protect water quality.	-Water quality studies in the Cimarron Watershed (referenced in the Cimarron Watershed Plan (CWA 2012). -Surface Water Quality Bureau study on the Canadian River, including tributaries (Cimarron River) (NMED 2010a) (referenced in the Cimarron Watershed Plan (CWA 2012) -Programmatic Guidance for Nonpoint Source Management (NMED 2009. New Mexico Environment Department Surface Water Quality Bureau. New Mexico Nonpoint Source Management Program 2009; and NMED 2010. New Mexico Environment Department Surface Water Quality Bureau July 29. 2010-2012 State of New Mexico Clean Water Act §303(d)/§305(b) Integrated Report.) (referenced in the Cimarron Watershed Plan (CWA 2012) -UNM Assessment of water quality in the Cimarron Watershed (UNM 2010) (referenced in the Cimarron Watershed Plan (University of New Mexico Water Resources Program, July 2010. Water Resources Assessment of the Cimarron River and Evaluation of Water Quality Characteristics at the Maxwell National Wildlife Refuge, Dr. Bruce Thomson and Dr. Abdul-Mehdi Ali, editors.)	Chris Cudia Environmental Specialist 505-827-2795 Chris.cudia@state.nm.us

Entity	Jurisdiction	Role	Data/Reports	Contact information
NM Forestry Division (NMSFD)	State	The NM State Forestry Division can assist landowners in working with other governmental organizations to find and secure necessary tools and funding to stabilize and restore their burned properties and watersheds. This can include advisement, planning assistance, and project design to help the applicant find the resources needed to complete restoration and stabilization projects.	The New Mexico State Forestry Division can also provide technical expertise regarding implementation of fuel reduction BMPs in the Cimarron Watershed. An excellent resource for communities post-fire is: "After Wildfire: A Guide for New Mexico Communities".[19] "Resources for Private Forest Landowners in New Mexico" provides resources for technical and financial assistance.[20] The "Forest Practices Guidelines" is also a useful reference for landowners. [21]	Susan Rich Forest and Watershed Health Coordinator 505-345-2080 susan.rich@state.nm.us Arnie Friedt Timber Management Officer 575-376-2204 Arnie.friedt@state.nm.us
New Mexico Department of Transportation (NMDOT)	State	Provide protection for U.S. Highway 64 and provide support the necessary equipment needed to clean mud and debris off the highway after large events. DOT is limited to the actions they can provide since the right of way is so narrow through the canyon.	Supplied report outlining the mitigation measures being taken to ensure safe travel on U.S. Highway 64	Trent Botkin Environmental Scientist 505-827-0585 trent.botkin@state.nm.us Jim Hirsch Environmental Scientist 505-827-5501 james.hirsch@state.nm.us
NM Forest and Watershed Restoration Institute (NMFRI) at New Mexico Highlands University	State	Forest Specialist on BAER Team Provide technical support to landowners.		Kent Reid Director 575-426-2145 rkreid@nmhu.edu
NM State University (NMSU)	State	Provide technical support to landowners.		Doug Cram Wildland Fire Specialist- Colfax County Extension dcram@nmsu.edu

[19] Interagency collaboration- After Wildfire- A Guide for New Mexico Communities: http://www.emnrd.state.nm.us/SFD/Publications/documents/AfterWildfireguide.pdf

[20] Resources for Private Forest Landowners in New Mexico: http://www.emnrd.state.nm.us/SFD/Publications/documents/ResourcesforPrivateForestLandowners2017_Updated171207.pdf

[21] NM State Forestry -Forest Practices Guideline: http://www.emnrd.state.nm.us/SFD/Publications/documents/NM_ForestPracticesGuidelines2008.pdf

Entity	Jurisdiction	Role	Data/Reports	Contact information
Office of the State Engineer (OSE)	State	Manages surface and groundwater throughout the project area.	Colfax Regional Water Plan (2016). [22]	Tim Farmer District 7 Supervisor 575-376-2918 Tim.farmer@state.nm.us Alfred (Buster) Chavez Cimarron-Rayado Water Master 575-376-2918 Alredc.chavez@state.nm.us
Philmont Scout Ranch	Private	Major landowner within burn area. Mitigation efforts to reduce impacts of post-fire flooding. Coordinating with all stakeholders.	Conservation Department – actively involved in watershed restoration along Rayado and Ponil Creek	John Celley Conservation Foreman 575-376-2281 John.celley@scouting.org Zach Seeger Land Manager/Forester Zach.seeger@scouting.org
City of Raton	State	Municipal water supply concerns.		Dan Campbell Water Works Manager dcampbell@cityofraton.com Kenneth Berry sberry@cityofraton.com
U.S. Forest Service	Federal	Technical Assistance/ Fire Suppression/ BAER BARC imagery of the Ute Park Fire Soil Burn Severity Map of the Ute Park Fire	BAER Guidelines[23],[24]	Wayne Robbie Supervisory Soil Scientist wrobbie@fs.fed.us

[22] Colfax Regional Water Plan: http://www.ose.state.nm.us/Planning/RWP/Regions/09_Colfax/2016/Reg%209_Colfax_Regional%20Water%20Plan%202016_July%202016.pdf

[23] BAER Handbook: https://www.nps.gov/archeology/npsGuide/fire/docs/18%20Interagency%20BAER%20Handbook.pdf

[24] BAER Treatments: https://www.fs.fed.us/t-d/pubs/pdf/BAERCAT/lo_res/06251801L.pdf

Entity	Jurisdiction	Role	Data/Reports	Contact information
U.S. Army Corps of Engineers (USACE)	Federal	Regulatory Program Authority. In the field on 6/14/18 to do assessments summarized in a report for DHSEM. Recommended mitigation actions. Support with sandbag installation.	The U.S. Army Corps of Engineers (USACE) can assist with permitting after a wildfire has occurred. A permit is required from the USACE for activities involving discharge of fill or dredged materials into bodies of water in the U.S.. Dredged material includes the redistribution of rocks, gravel and sediments already in the stream, lake, pond, wetland, etc. Under Section 404 of the Clean Water Act a permit is required from the USACE for activities involving discharge of fill or dredged materials into waters of the United States (WOUS). This requirement is not waived in emergency situations. USACE regulations at 33 CFR 325.2(e)(4) define an emergency as a situation that "…would result in an unacceptable hazard to life, a significant loss of property or an immediate, unforeseen and significant economic hardship…"Projects associated with emergency and disaster response situations will receive priority review and expedited response. Potential responses include informing the applicant that a permit is not required for the proposed work, that the project meets the terms and conditions of an issued general permit, or that an individual permit is required.	Allan Steinle 505-342-3282 Allan.E.Steinle@usace.army.mil Donald Gallegos Operations and Readiness Donald.j.gallegos@usace.army.mil Stephen Scissons Hydrology and Hydraulics Stephen.k.scissons@usace.army.mil http://www.spa.usace.army.mil/Missions/RegulatoryProgramandPermits.aspx
U.S. Geological Survey (USGS)	Federal	Short term gage installation and data collection, research on hazards caused by wildfire.	Provide streamflow measurements and rainfall data following significant events Provided debris flow modelling – compiled on RECOVER website.	Jeffrey Cordova Chief- Rio Arriba Field Office 505-350-4174 jcordova@usgs.gov
Community of Ute Park	Municipal	Private landowners/community members	NA	Jim Rockenfield Fire Chief 575-643-9600
Vermejo Park Ranch	Private	Private landowner within burn area	NA	Gus Holm General Manager 575-445-2059 Gus.holm@vermejo.com

APPENDIX C – FUNDING MATRIX

Table C.1. Funding Sources for Watershed Restoration and Post-Fire Rehabilitation

Entity	Funding Program	Funding Program/ Description	Funding cycle	Total amount	Contact Information	ID
Federal and State Funding						
FEMA Hazard Mitigation Assistance Grants administered by New Mexico DHSEM	Hazard Mitigation Grant Program (HMGP)	The Hazard Mitigation Grant Program (HMGP) provides sub-grants to state agencies, local governments, tribes and non-profits to implement long-term hazard mitigation measures after a Major Disaster Declaration. Authorized under Section 404 of the Robert T. Stafford Disaster Relief and Emergency Assistance Act and administered by FEMA, HMGP was created to reduce the loss of life and property due to natural disasters. Construction and land disturbance projects require benefit cost analysis and environmental clearance. Eligible activities include: -minor localized flood reduction -watershed and soil stabilization -wildfire mitigation -flood-prone structure acquisition/structure demolition -aquifer storage and recovery -floodplain and stream restoration -flood diversion and storage -generators for critical facilities -5% "Initiative" Projects; risk assessments; outreach and education; weather station/warning systems/sirens -natural hazard mitigation plans.	Submittal of Notices of Interest for mitigation funding are encouraged as soon as possible so that applications are complete and ready for submission to FEMA as soon as funds become available. When funds become available, DHSEM sets the deadline for Notice of Interest and application submittal. Contact DHSEM for application/award process	The amount of HGMP funding available to the applicant is based on 15% of the FEMA Public Assistance grant used to recovery after a Presidential disaster declaration. Only permanent repair work is used to calculate HMGP (Public Assistance Categories C – G) FEMA provides up to 75% for mitigation projects/plans. 25% non-federal match can be in the form of cash and/or in-kind.	Wendy Blackwell, CFM State Hazard Mitigation Officer 505-476-9676 office wendy.blackwell@state.nm.us https://www.fema.gov/hazard-mitigation-grant-program And, http://www.nmdhsem.org/Grants.aspx	A

Entity	Funding Program	Funding Program/ Description	Funding cycle	Total amount	Contact Information	ID
	Pre-Disaster Mitigation (PDM)	PDM Program aims to reduce overall risk to the population and structures from hazard events. PDM is funded annually by Congressional appropriation. authorized by Section 203 of the Robert T. Stafford Disaster Relief and Emergency Assistance Act. Eligible sub-grantees are state agencies, local governments, tribes and non-profits. Construction and land disturbance projects require benefit cost analysis and environmental clearance. Eligible activities include: -minor localized flood reduction -watershed and soil stabilization -wildfire mitigation -flood-prone structure acquisition/structure demolition -aquifer storage and recovery -floodplain and stream restoration -flood diversion and storage -generators for critical facilities (must meet benefit cost analysis criteria) -natural hazard mitigation plans	August 3, 2018 – FFY18 Notice of Funding Opportunity released September- Notice of Interest deadline anticipated November – Full application deadline anticipated December 2019 – Awards anticipated	There is a federal share set-aside for each state, tribe and territory ($575,000 set aside for FFY18). Additional funds are made available for award in a national competition. FEMA provides 75% for mitigation projects/plans. 25% non-federal match can be in the form of cash and/or in-kind. Small, impoverished communities are eligible for up to a 90% federal cost share.	Wendy Blackwell, CFM State Hazard Mitigation Officer 505-476-9676 office wendy.blackwell@state.nm.us https://www.fema.gov/pre-disaster-mitigation-grant-program And, http://www.nmdhsem.org/Grants.aspx	B
	Flood Mitigation Assistance (FMA)	The FMA provides funding for projects that reduce or eliminate long-term risk of flood damage to structures insured under the NFIP. Funding is appropriated by Congress annually and all awards are based on a national competition. FMA is authorized by Section 1366 of the National Flood Insurance Act of 1968. Construction and land disturbance projects require benefit cost analysis and environmental clearance. Eligible activities include: -minor localized flood reduction -flood-prone structure acquisition/structure demolition -floodplain and stream restoration -flood diversion and storage	August 3, 2018 – FFY18 Notice of Funding Opportunity released September- Notice of Interest deadline anticipated November – Full application deadline anticipated December 2019 – Awards anticipated	FEMA provides 75% for mitigation projects. 25% non-federal match can be in the form of cash and/or in-kind. Increased federal cost share is available for acquisition of NFIP Repetitive Loss and Severe Repetitive Loss structures.	Wendy Blackwell, CFM State Hazard Mitigation Officer 505-476-9676 office wendy.blackwell@state.nm.us https://www.fema.gov/flood-mitigation-assistance-grant-program And, http://www.nmdhsem.org/Grants.aspx	C

Entity	Funding Program	Funding Program/ Description	Funding cycle	Total amount	Contact Information	ID
	State Disaster Assistance Program	The purpose of the State DAP is to determine if there is sufficient eligible damage in the public sector to recommend a Governor's Executive Order declaring a disaster, or to provide assistance under the Disaster Assistance Program. DHSEM will work with local government officials to identify and contact all possible applicants within their jurisdiction following the issuance of the disaster Executive Order. Eligible Applicants: •Any local government may apply for disaster assistance, including municipalities, counties, and tribal governments. •Special districts created by legislative action are eligible to apply (example: irrigation districts or solid waste districts). •Community ditch associations and Land Grants, organized according to State statute, are eligible to apply. •Private non-profit organizations that provide a governmental service are eligible to apply as long as they are not commercial in nature (example: N.M. Gas and PNM are not eligible). •Community centers or houses of worship open to the general public, without regard to their secular or religious nature. •Applicants will be required to provide a financial statement showing that they are in a condition of financial hardship and do not have sufficient funds to cover their losses. For local governments, the Department of Finance and Administration may help establish financial hardship. •State agencies may apply. •The Department of Military Affairs (National Guard) may apply. DHSEM will assemble a PDA team to visit each identified applicant in the affected area. The purpose of this visit is to view each applicant's qualifying damage site and make a detailed estimate of the cost of restoring that site to its pre-event condition. A PDA team will develop an estimate of public infrastructure damages by category. Furthermore, they will report their observations on the continuing threat to lives, public health and safety	DHSEM coordinates all requests for assistance. Applicants requesting financial assistance from the State shall be required to demonstrate that the cost of the necessary actions exceeds their available resources as determined by criteria developed in conjunction with the State agencies (if any) with financial and budgetary oversight responsibilities for the applicant.	The amount of State DAP funding available to the applicant is based on the specific Executive Order signed by the Governor.	Matthew Smith Recovery Officer NMDHSEM, Response and Recovery Bureau P.O. Box 27111, Santa Fe, NM 87502 505-469-1556 cell Matthew.Smith5@state.nm.us Rosalita M. Whitehair Recovery Unit Manager NMDHSEM. Response and Recovery Bureau P.O. Box 27111, Santa Fe, NM 87502 505-476-9601 Office 505-280-6664 Cell Rosalita.Whitehair@state.nm.us Further information, along with the State DAP guide, is available upon request.	D

Entity	Funding Program	Funding Program/ Description	Funding cycle	Total amount	Contact Information	ID
		and property, the general condition of housing in the area, and other possible social and economic impacts The state DAP is a monetary assistance program, which is a cost share of not less than 75% State cost share and a non-State cost share of 25%, reimbursed after all closing cost documentation has been submitted and reviewed.				
	Fire Management Assistance Grant (FMAG)	FEMA grant program specifically used as reimbursement for fire suppression activities, prepositioning activities, emergency services due to the fire, and temporary repair of damaged facilities caused by fire suppression. Funds are used to reimburse eligible applicants which include: state agencies, local governments, Indian tribal governments. Ute Park Fire Management Assistance Declaration declared occurred on June 01, 2018 and declared controlled on July 31, 2018. FM-5239: https://www.fema.gov/disaster/5239 The FMAG program is authorized by section 420 of the Stafford Act (42 U.S.C. 5187). https://www.fema.gov/media-library-data/1394820975537-a279bff2a4a300676b870154acec922b/FMAG%20Guide%20Feb%202014_508.pdf	FMAG Request for Public Assistance (RPA) Incident Period : May 31, 2018- June 17, 2018 Application Issued: May 31, 2018. Application deadline (30 days after the incident period ends): July 17, 2018 FMAG RPA: http://www.nmdhsem.org/Resources.aspx	Funding is variable based on FMAG and applicant. Reimbursement is based on 100% completed claimed costs when submitted to DHSEM. The claimed costs are reimbursed at 75% Federal Share and 25% Local Share. FMAG Reimbursement Forms: http://www.nmdhsem.org/Resources.aspx	Matthew Smith Recovery Officer NMDHSEM Response and Recovery Bureau 505-469-1556 Cell Matthew.Smith5@state.nm.us Rosalita Whitehair Recovery Unit Manager NMDHSEM Response and Recovery Bureau 505-476-0613 Office 505-280-6664 Cell Rosalita.Whitehair@state.nm.us	E
	Fire Management Assistance Grant- Post Fire (FMAG-PF)	New FEMA grant program specifically for post fire assistance to provide for long term mitigation of burn scar areas and acreage downstream that could be impacted. Eligible sub-grantees are state agencies, local governments, tribes and non-profits. If funds are not utilized by the communities impacted by the FMAG, the state can provide funding to any eligible applicant for any natural hazard mitigation activity. The Bipartisan Budget Act of 2018 authorizes FEMA to provide assistance for October 1, 2016 to September 30, 2018. Construction and land disturbance projects require benefit cost analysis and environmental clearance.	September- Notice of Interest deadline anticipated January – Full application deadline anticipated Fall 2019 – Awards anticipated	$425,008 for each New Mexico FMAG because we have a Standard Natural Hazard Mitigation Plan. Ute Park Fire impacted communities are the first priority for $425,008.	Wendy Blackwell, CFM State Hazard Mitigation Officer 505-476-9676 office wendy.blackwell@state.nm.us https://www.fema.gov/hazard-mitigation-grant-program-post-fire	F

Entity	Funding Program	Funding Program/ Description	Funding cycle	Total amount	Contact Information	ID
USDA/EPA/ U.S. Endowment for Forestry and Communities	Healthy Watersheds Consortium (HWC)	The goal of the HWC Grant Program is to “accelerate strategic protection of healthy, freshwater ecosystems and their watersheds”, with primary focus on prevention of deterioration in the watershed by: - Developing funding mechanisms, plans or other strategies to implement large scale watershed protection, source water protection, green infrastructure, or related landscape conservation objectives. Grants focus on three categories: 1) short-term funding to leverage larger financing for targeted watershed protection; 2) funds to help build the capacity of local organizations for sustainable, long-term watershed protection; and 3) new techniques or approaches that advance the state of practice for watershed protection and that can be replicated across the country. Eligibility- Not-for-profit 501(c)(3) organizations, for-profit companies, tribes, intertribal consortia, interstates, state, and local government agencies including water utilities and wastewater facilities, and colleges and universities are eligible for funding. Unincorporated individuals and federal agencies are not eligible. Public/private partnerships are particularly desirable. Eligible projects would include: -Protect drinking water sources and watersheds -Develop watershed protection plans -Implement protection related activities in existing watershed, source water, or similar plans.	RFP issued July 19th 2018. Application Deadline February 4th 2019 RFP: http://www.usendowment.org/images/HWC_RFP_Yr_4_2019_7.18.2018.pdf	~ $100,000- 300,000. Matching funds required: http://www.usendowment.org/images/HWC_2018_FAQs.pdf	Program Website: http://www.usendowment.org/healthywatersheds.html Chief Operating Officer- Peter Stangel 404-915-2763, peter@usendowment.org	G

Entity	Funding Program	Funding Program/ Description	Funding cycle	Total amount	Contact Information	ID
USDA Natural Resource Conservation Service (NRCS)	Environmental Quality Incentives Program (EQIP)	The Environmental Quality Incentives Program (EQIP) is a voluntary program authorized under the Agricultural Act of 2014 (2014 Farm Bill) that helps producers install measures to protect soil, water, plant, wildlife, and other natural resources while ensuring sustainable production on their farms, ranches and working forest lands. As part of a new national directive starting in 2012, NRCS is setting aside 5% of the EQIP budget for work on priority watersheds to address waters on the Integrated 305(b)/303 (d) Report (NMED, 2010b). The primary focus is nutrients and sediment, however, funding can address other listed constituents. The EQIP program could be used to help private landowners fund improved stream-crossing and other farming and ranching BMPs identified in Section 7. Relevant national priorities include: - Reductions of non point source pollution, such as nutrients and sediment, the reduction of surface and groundwater contamination; -Conservation of ground and surface water resources; -Reduction in soil erosion and sedimentation. Potential for EQIP funding through the Watershed Initiative. Upper Dry Cimarron is part of the Initiative.	Application deadlines for 2018 funding was December 2017.	Payments are made to participants after conservation practices and activities identified in an EQIP plan of operations are implemented. Contracts can last up to ten years in duration. A single contract may not exceed $450,000 and the total amount of payments to a person or legal entity may not exceed an aggregate of $450,000, directly or indirectly, for all contracts, enrolled in EQIP beginning February 7, 2014, through fiscal year 2018. Payments received for technical assistance are excluded from this limitation.	Kenneth Branch Resource Conservationist State Office: 6200 Jefferson Street N. E.Albuquerque, NM 87114 (505) 761-4454 Kenneth.branch@nm.usda.gov Website: https://www.nrcs.usda.gov/wps/portal/nrcs/detail/nm/programs/financial/eqip/?cid=nrcs144p2_068634	H

Entity	Funding Program	Funding Program/ Description	Funding cycle	Total amount	Contact Information	ID
	Emergency Watershed Protection Program (EWPP)	The program offers technical and financial assistance to help local communities relieve imminent threats to life and property caused by floods, fires, windstorms and other natural disasters that impair a watershed. Eligible sponsors include cities, counties, towns, conservation districts, or any federally-recognized Native American tribe or tribal organization. Interested public and private landowners can apply for EWP Program – Recovery assistance through one of those sponsors. EWPP covers the following activities: -Debris removal from stream channels, road culverts and bridges -Reshape and protect eroded streambanks -Correct damaged drainage facilities -Establish vegetative cover on critically eroded lands -Repair levees and structures -Repair conservation practices.	If funding becomes available, all funded projects must demonstrate they reduce threats to life and property; be economically, environmentally and socially sound; and must be designed to acceptable engineering standards, if applicable.	NRCS can pay up to 75 percent of the cost for eligible emergency projects. Local sponsors must acquire the remaining 25 percent in cash or in-kind services.	Kenneth Branch Resource Conservationist State Office: 6200 Jefferson Street N. E. Albuquerque, NM 87114 (505) 761-4454 Kenneth.branch@nm.usda.gov Local office: USDA Raton 245 PARK AVE RATON, NM 87740-3800 Phone: (575) 445-9571 ext 3 Fax: (855) 538-5999 For info: https://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/programs/landscape/ewpp/?cid=nrcseprd1381472	I

Entity	Funding Program	Funding Program/ Description	Funding cycle	Total amount	Contact Information	ID
	Watershed and Flood Prevention Operations Program	The Watershed Protection and Flood Prevention Program helps units of federal, state, local and tribal of government (project sponsors) protect and restore watersheds up to 250,000 acres. USDA's Natural Resources Conservation Service (NRCS) offers financial and technical assistance through this program for the following relevant purposes: -Erosion and sediment control -Watershed protection -Flood prevention -Water quality Improvements -Rural, municipal and industrial water supply -Water management -Fish and wildlife habitat enhancement Must have a public entity as a sponsor. Project sponsors access program assistance through the Watershed and Flood Prevention **Operations** component of this program. Project sponsors can use land treatment solutions or structural solutions, which require construction. An approved watershed plan must be in place prior to initiation of any corrective land treatment or structural solutions. Once the watershed plan is approved, the project sponsor helps landowners install planned land treatment measures if that is the appropriate solution. For structural solutions, project sponsors ensure surveys and investigations are completed. They also acquire detailed designs, specifications and engineering cost estimates for construction projects. If needed, project sponsors will outline areas where land rights, easements, and right-of-ways are needed.	Watershed and Flood Prevention Operations funding is available pending the following: -Annual Congressional appropriations; -State and national priorities; -Acquisition of land and water rights; -Obtaining required permits; -Availability of local funding for specific project solutions; -Completion of structural, agronomic and vegetative designs for project measures; -An approved Operations and Maintenance agreement between NRCS and the project sponsor that ensures the project land treatment and/or structural solutions will be installed and maintained as specified in the agreement.	See website: https://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/landscape/wfpo/	Kevin Farmer, Watershed Programs Team Leader, at Kevin.Farmer@wdc.usda.gov or call 202-720-3413.	J

Entity	Funding Program	Funding Program/ Description	Funding cycle	Total amount	Contact Information	ID
USDA Rural Development	Water and Waste Disposal Loan and Grant Program	This program provides funding for clean and reliable drinking water systems, sanitary sewage disposal, sanitary solid waste disposal, and storm water drainage to households and businesses in eligible rural areas. This program assists qualified applicants who are not otherwise able to obtain commercial credit on reasonable terms. Eligible applicants include: -Most state and local governmental entities -Private nonprofits -Federally-recognized tribes -Rural areas and towns with populations of 10,000 or less Funds may be used to finance the acquisition, construction or improvement of: -Drinking water sourcing, treatment, storage and distribution -Sewer collection, transmission, treatment and disposal -Solid waste collection, disposal and closure Storm water collection, transmission and disposal	Applications currently being accepted	-Long-term, low-interest loans; -If funds are available, a grant may be combined with a loan if necessary to keep user costs reasonable.	State Office, Albuquerque, NM Phone: 505-761-4950 E-Mail: CPAssist@nm.usda.gov Fact sheet: https://www.rd.usda.gov/files/fact-sheet/RD-FactSheet-RUS-WEPDirect.pdf	K
	Emergency Community Water Assistance Grants	Helps eligible communities prepare for, or recover from, an emergency that threatens the availability of safe, reliable drinking water for households and businesses. Areas that may be served include Rural areas and towns with 10,000 or fewer people and the area to served must have a median household income less than the states median household income for non-metropolitan areas. Funds may be used for: - Water transmission line grants up to $150,000 are for construction of waterline extensions, repairs to breaks or leaks in existing water distribution lines, and related maintenance necessary to replenish water supply. Water source grants up to $500,000 are for the construction of a new water source, intake and/or treatment facility. Partnerships with other federal, state, local, private and NGOs are encouraged.	Applications for this program are accepted year round through your local RD office.	No matching funds required.	For information: CPAssist@nm.usda.gov https://www.rd.usda.gov/programs-services/emergency-community-water-assistance-grants/nm	L

Entity	Funding Program	Funding Program/ Description	Funding cycle	Total amount	Contact Information	ID
USDA Farm Service Agency (FSA)	Emergency Conservation Program (ECP)	The Emergency Conservation Program (ECP) helps farmers and ranchers to repair damage to farmlands caused by natural disasters and to help put in place methods for water conservation during severe drought. The ECP does this by giving ranchers and farmers funding and assistance to repair the damaged farmland or to install methods for water conservation. Could be used for restoring conservation structures (waterways, diversion ditches, buried irrigation mainlines and permanently installed ditching system)	Check with local FSA office regarding sign-ups periods.	The funding for ECP is determined by Congress. Up to 75% of the cost to implement emergency conservation practices can be provided, however the final amount is determined by the committee reviewing the application. Qualified limited resource producers may earn up to 90% cost-share. The FSA County Committee is able to approve applications up to $50,000 while $50,001 to $100,000 requires state committee approval. Amounts over $100,000 require the approval of the national FSA office. Limited to $200,000 per legal entity per disaster	FSA Service Center Office Colfax County FSA 245 Park Ave Raton, NM, 87740 575 445-9471 ECP Fact Sheet: https://www.fsa.usda.gov/Assets/USDA-FSA-Public/usdafiles/FactSheets/2017/emergency_conservation_program_oct2017.pdf NM FSA Fact Sheet: https://www.fsa.usda.gov/state-offices/New-Mexico/index	M

Entity	Funding Program	Funding Program/ Description	Funding cycle	Total amount	Contact Information	ID
	Emergency Forest Restoration Program (EFRP)	The Emergency Forest Restoration Program (EFRP) helps the owners of non-industrial private forests restore forest health damaged by natural disasters. The EFRP does this by authorizing payments to owners of private forests to restore disaster damaged forests. The local FSA County Committee implements EFRP for all disasters with the exceptions of drought and insect infestations. In the case of drought or an insect infestation, the national FSA office authorizes EFRP implementation. Eligible practices may include: -Debris removal, such as down or damaged trees, in order to establish a new stand or provide for natural regeneration. -Site preparation, planting materials and labor to replant forest stand; -Restoration of forestland roads, fire lanes, fuel breaks or erosion control structures; -Fencing, tree shelters and tree tubes to protect trees from wildlife damage; -Wildlife enhancement to provide cover openings and wildlife habitat; To be eligible for EFRP land must: -Have existing tree cover (or had tree cover immediately before the natural disaster occurred and is suitable for growing trees); and -Be owned by any nonindustrial private individual, group, association, corporation or other private legal entity.	Inquire with local FSA county office regarding EFRP enrollment periods and eligibility	Cost-share payments are: -Up to 75 percent of the cost to implement approved restoration practices; and -Limited to $500,000 per person or legal entity per disaster.	FSA Service Center Office Colfax County FSA 245 Park Ave Raton, NM, 87740 575-445-9471 EFRP Factsheet: https://www.fsa.usda.gov/Assets/USDA-FSA-Public/usdafiles/FactSheets/2017/emergency_forest_restoration_program_oct2017.pdf	N

Entity	Funding Program	Funding Program/ Description	Funding cycle	Total amount	Contact Information	ID
U. S. Army Corp of Engineers (USACE)	Permanent Flood Protection Solutions	USACE has the authority to construct large-scale flood risk management (FRM) projects, including dams and engineered levees, through the Civil Works Program. Smaller-scale FRM projects may be constructed through the Corps' Continuing Authorities Program. Section 205 of the Flood Control Act of 1948 provides authority to construct FRM projects with up to a $7 million Federal cost. USACE resources can only be requested by a State Emergency Management Agency or by Tribal governments, and can only occur once State, Tribal and local governments have committed all available resources (i.e., workforce, supplies, equipment, funds, National Guard assets, etc.).	Funding availability is subject to the budget cycle.	These projects are cost-shared 65/35 Federal/non-Federal. FRM projects are cost-shared and require a non-Federal sponsor. Cost-sharing varies from feasibility phase (50/50 Fed/non-Fed) to construction phase (65/35 Fed/non-Fed). However, Assistance can be requested at anytime.	Kristopher Schafer 505-342-3201 Kristopher.T.Schafer@usace.army.mil	O
USDI United States Bureau of Reclamation (USBOR)	WaterSMART Cooperative Watershed Management Program Grants Phase I and Phase II grants.	Through WaterSMART, Reclamation leverages Federal and non-Federal funding to support stakeholder efforts to stretch scarce water supplies and avoid conflicts over water. The Cooperative Watershed Management Program (CWMP) contributes to the Department's priorities to create a legacy of conservation stewardship and restore trust with local communities by providing funding to grassroots, local watershed groups to encourage diverse stakeholders to develop collaborative solutions to address their water management needs. In accordance with the authority for the CWMP, Reclamation may fund the development of watershed groups and watershed restoration planning (Phase I) and the implementation of on-the-ground watershed management projects (Phase II). Eligible applicants include States, Indian tribes, local and special districts (e.g., irrigation and water districts, etc.), local governmental entities, interstate organizations, and non-profit organizations.	~ January application deadline	Up to $100,000 in Federal funds may be awarded to an applicant per award, with no more than $50,000 made available in each year for a period of up to two years. A non-Federal cost share contribution is not required for Phase I CWMP activities funded under this FOA.	Regional Contact- Upper Colorado Region: Brandi Rose, (801) 524-3639 Website- https://www.usbr.gov/watersmart/cwmp/ Example Phase II funding announcement: https://www.usbr.gov/watersmart/cwmp/docs/2017/2017-CWMP-FOA-12-15-2016.FINAL.pdf	P

Entity	Funding Program	Funding Program/ Description	Funding cycle	Total amount	Contact Information	ID
The National Fish and Wildlife Foundation and NRCS	Conservation Partners Programs	Private landowners are responsible for the use and management of more than two-thirds of the land in the U.S., including some of its most important fish and wildlife habitat. Grants funded through the Conservation Partners program are intended to provide staff and technical assistance to private landowners in regions where some of the nation's most crucial conservation issues can be addressed through Farm Bill programs. Specifically, the program will support technical assistance to producers to help accelerate implementation of NFWF initiatives and Farm Bill conservation programs; the incorporation of the best available science in applying conservation systems and strategically focusing resources where the greatest conservation opportunities exist; increased landowner/manager awareness and participation in NRCS/NFWF initiatives and Farm Bill programs; and/or identifying and promoting positive economic outcomes as a result of conservation system implementation.	Proposal deadline: 8/22/18. RFP: http://www.nfwf.org/conservationpartners/Pages/2018rfp.aspx	The 2018 Conservation Partners Program will award approximately $5.1 million in NRCS funds. Typical grant awards will range between $50,000 and $300,000. Projects may be funded for up to three years from the completion of the grant agreement. For all requests, a match of at least one-to-one non-federal cash or in-kind is required.	Current RFP: http://www.nfwf.org/conservationpartners/Pages/2018rfp.aspx	Q

Entity	Funding Program	Funding Program/ Description	Funding cycle	Total amount	Contact Information	ID
U.S. Fish and Wildlife Service (USFWS)	Partners for Fish and Wildlife Small Grant Program.	The Program provides technical and financial assistance to private landowners, tribes and schools on a voluntary basis to help meet the habitat needs of federal trust species. Field biologists work one-on-one with landowners and partners to plan, implement and monitor activities. The Partners Program can assist with projects in all habitat types which conserve or restore native vegetation, hydrology, and soils associated with imperiled ecosystems. Partners Program field staff help landowners find other sources of funding and help them through the permitting process, as necessary. If other considerations are generally equal, then priority is directed to those projects that link private lands to important Federal lands (such as Refuges), have cooperative agreements of longer duration, multiple partners, cost sharing, and the greatest cost effectiveness. The overall goal of Partners Program projects is to return a site to the ecological condition that likely existed prior to loss or degradation. Through voluntary agreements the Partners program provides expert technical assistance and cost-share incentives directly to private landowners to restore fish and wildlife habitats. Any privately-owned land is potentially eligible for restoration. Most participants are individual private landowners.	To implement a project, a cooperative agreement with a minimum duration of 10 years is signed. The landowner is reimbursed after project completion, based on the cost-sharing formula in the agreement.	Various.	Gwen Kolb U.S. Fish & Wildlife Service 2105 Osuna road NE Albuquerque, NM 87113 505 761-4711 Email: gwen_kolb@fws.gov	R
New Mexico Finance Authority (NMFA)	Water Trust Board (WTB) Water Project Fund Watershed restoration and management projects	The 2001 Legislature enacted the Water Project Finance Act which created the Water Project Fund in the NM Finance Authority (NMFA) and charged the NMFA with the administration of the Fund and the Water Trust Board (WTB). The WTB funding process includes a separate category for watershed restoration projects. Projects that protect the water quality of drinking water supplies, as listed in Section 7, would be eligible for this funding, particularly those related to surface water sources which provide drinking water supplies.	Funding applications can be completed and submitted only by an eligible public entity. Application deadline for 2019 is October 4th. Timeline for 2019 applications is here: https://www.nmfa.net/wp-content/uploads/2018/07/2019-WTB-Application-Timeline.pdf	< $1,00,000.	For information: WTBAdmin@nmfa.net – (505) 984-1454	S

Entity	Funding Program	Funding Program/ Description	Funding cycle	Total amount	Contact Information	ID
	Drinking Water State Revolving Loan Fund	Drinking Water State Revolving Loan Fund ("DWSRLF") is operated in partnership with the New Mexico Environment Department ("NMED") to provide low-cost financing for the construction of and improvements to drinking water facilities throughout New Mexico in order to protect drinking water quality and the public health. Priorities of the program include: -Protection of public health -Compliance with drinking water standards -Affordable access to water Community water systems and non-profit non-community water systems are eligible to apply for DWSRLF funding. Projects that protect drinking water quality and public health are eligible for the DWSRLF, including: -New and replacement water sources -Treatment; -Transmission and distribution lines; -Storage; -Supervisory Control and Data Acquisition (SCADA) systems; and, -Infrastructure to interconnect or regionalize water systems.	Application information here: https://www.nmfa.net/financing/water-programs/drinking-water-revolving-loan-fund/	This federally funded program, managed by the NMFA on behalf of the State of New Mexico, is funded through a federal capitalization grant of approximately $8 million annually. The State is required to match the federal grant by 20 percent. The primary use of the funding is for zero or two-percent loans to drinking water systems to fund vital water quality projects.	Todd Johansen Sr. Program Administrator, (505) 992-9654 – tjohansen@nmfa.net Mary Finney Water Resources Administrator, (505) 992-9658 – mfinney@nmfa.net	T
	Local Government Planning Funds (Formerly Known as the Water and Wastewater Planning Fund)	The fund provides up-front capital necessary for proper planning of vital public projects, including infrastructure, water and wastewater preliminary engineering reports, long-term master plans, water conservation plans, economic development plans or energy audits.	Applications for the Local Government Planning Fund will be considered by the Board quarterly at the NMFA's February, May, August and November Board Meetings. Applications must be submitted approximately six weeks prior to the Board Meeting. Applications for urgent or emergency projects will be considered monthly.	$50,000	New Mexico Finance Authority 207 Shelby Street Santa Fe, NM 87501 PHONE: (505) 984-1454 PHONE: 1-877-ASK-NMFA	U

Entity	Funding Program	Funding Program/ Description	Funding cycle	Total amount	Contact Information	ID
New Mexico Environment Department (NMED)- Surface Water Quality Bureau	Federal Clean Water Act Section 319 Grant: Watershed Based Planning	The objective of watershed-based planning is to identify effective strategies for water quality improvement sufficient for the impairment designation to be removed, and to foster the coordination and cooperation required for effective implementation. Eligible groups include citizen watershed groups, non-profit organizations, for-profit organizations, individuals, and federal, state and local agencies (including those of Indian Nations, Pueblos, and Tribes).	January application deadline	$200,000 (in 2018 cycle). 40% match (cash or in-kind required)	For information: https://www.env.nm.gov/surface-water-quality/wbp https://www.env.nm.gov/wp-content/uploads/2017/06/FY18-319-WBP-Notice-for-Grant-Application.pdf	V
NMED- Construction Program Bureau	Rural Infrastructure Loan Program	The purpose of the RIP is to provide financial assistance to eligible local authorities for the construction or modification of water supply, wastewater, and solid waste facilities. The funds are state monies, and the application and approval process is streamlined, allowing the funds to be available within six to eight weeks. Any incorporated City, Town, Village, Mutual Domestic Water Consumers Association (MDWCA) or Water and Sanitation Districts with a population of less than twenty thousand or a county that serves a population of less than two hundred thousand. These types of projects can be financed through RIP: -Eligible water, wastewater and solid waste -Water pipelines -New sewer interceptors and collectors -Infiltration/inflow correction -Water and sewer system rehabilitation -Treatment plant improvements -Non-point source projects (i.e., septic tanks) -Cost of water rights acquisition -Eligible solid waste facilities including collection, disposal, storage and recycling -Engineering studies and design -Project inspection -Easement and right-of-way -Project legal costs -Purchase of equipment -Pollution Control	Applications are accepted throughout the year. Loan funds can be made available for projects within six to eight weeks upon submission of complete application.	The maximum loan per entity is $2,000,000 per year. Grant funding may be available on a limited basis. The base interest rate is 2.375%, with a repayment schedule of up to 20 years. The first payment is not due until one year after the completion of the project	contact the CPB Team: NMENV-cpbinfo@state.nm.us or (505) 827-2806.	W

Entity	Funding Program	Funding Program/ Description	Funding cycle	Total amount	Contact Information	ID
	EPA Clean Water State Revolving Funds (CWSRF). Managed by the NMED in NM.	Provide low interest loans to fund water quality protection for wastewater treatment, nonpoint source pollution control, and watershed management. Local governments, farmers and nonprofit groups such as the CWA are eligible recipients. The ability to repay the loan will be central to applicability in the Cimarron Watershed. The most likely projects to be funded through this program would be projects that could be addressed through local government participation. Using a combination of federal and state funds, state CWSRF programs provide loans to eligible recipients to: -construct municipal wastewater facilities, -control nonpoint sources of pollution, -build decentralized wastewater treatment systems, -create green infrastructure projects, -protect estuaries, and -fund other water quality projects.	Applications are accepted annually each Spring. A submitted application does not obligate a borrower to accept funding.	WSRF programs function like environmental infrastructure banks by providing low interest loans to eligible recipients for water infrastructure projects. CWSRF loans are offered at below market rates, ranging from 0% to 2.375% depending on census and economic criteria. Loan repayment terms up to 30 years.	CPB CWSRF Team email: NMENV-cpbinfo@state.nm.us or (505) 827-2806. Website: https://www.env.nm.gov/construction-programs/clean-water-state-revolving-fund-cwsrf/	X
New Mexico State Forestry Division (NMSFD)	Invasive Plant Management	Invasive plant management activities where noxious weed invasions threaten forest health, address species on the NM Department of Agriculture's "Noxious Weed List" and are encouraged to be within a Cooperative Weed Management Area (CWMA) on non-federal lands or demonstrate partnership with a CWMA. Components of the projects may include: integrated weed management, mapping and inventory, monitoring, early detection and prevention, planning and coordination, and awareness and education. Non-federal government entities can apply.	Grant deadline – October (the Request for Proposals typically comes out in August or September).	Grant amount varies, no fixed min or max amount. 50% non-federal match required.	NM State Forestry Shannon Atencio, 505-425-7472, shannon.atencio@state.nm.us	Y
	Seedling Program	NMSF offers tree and shrub seedlings for sale to landowners who own at least one acre of land in New Mexico and who agree to use the seedlings for conservation purposes. Approximately 45 species of tree and shrubs are available.	N/A	N/A	Visit www.nmforestry.com for more information NM State Forestry Carol Bada 505-476-3334 carol.bada@state.nm.us	Z

Entity	Funding Program	Funding Program/ Description	Funding cycle	Total amount	Contact Information	ID
	Forest Health Initiative	Provides cost share funds for the reduction of insect and pathogen (disease) risk through forest improvement. The objective is to improve degraded (e.g., overcrowded, infested, and/or infected) forested land to a healthier, more resilient state. Landowners must have a minimum of 10 acres of forested land with a stewardship plan in place (up to 10% of program funds are available to write plans). Eligible applicants include private landowners or state and local government owners of forest or woodlands.	Deadline varies depending on funding	Grant amounts vary, up to $100,000. 30% non-federal match.	NM State Forestry John Formby 505-476-3351 john.formby@state.nm.us	
Private Funding						
Americorp	The AmeriCorps Volunteers in Service to America (VISTA)	Program places volunteers in positions that will provide them with training and experience to improve their prospects for future employment. Non-profit entities, for example the CWA could provide training, oversight, and a work place for a VISTA volunteer to help with project coordination and implementation of key projects.	N/A	N/A	Information: https://www.nationalservice.gov/focus-areas/environmental-stewardship	AA
Audubon Society	Together Green Innovation Grants	Together Green grants fund projects that: conserve or restore habitat and protect species, improve water quality or quantity, and reduce the threat of global warming; engage new and diverse audiences in conservation actions; and inspire and use innovative approaches and technologies to engage people and achieve conservation results. Innovation Grants awards go to organizations in the Audubon network, working with partners in their communities, who have the passion, commitment, and vision to move people to take action and achieve lasting conservation results.	N/A	N/A	Information: http://www.togethergreen.org/Projects/Grantee.aspx	AB

Entity	Funding Program	Funding Program/ Description	Funding cycle	Total amount	Contact Information	ID
National Fish and Wildlife Foundation	Bring Back the Natives	The Bring Back the Natives program invests in conservation activities that restore, protect and enhance native populations of sensitive or listed fish species across the United States, especially in areas on or adjacent to federal agency lands. The program emphasizes coordination between private landowners and federal agencies, tribes, corporations, and states to improve the ecosystem functions and health of watersheds. The end result is conservation of aquatic ecosystems, increase of in-stream flows, and partnerships that benefit native fish species throughout the United States. Eligible applicants include: local, state, federal, and tribal governments and agencies (e.g., townships, cities, boroughs), special districts (e.g., conservation districts, planning districts, utility districts), non-profit 501(c) organizations, schools and universities. Priority activities include: -Restoring connectivity Restoring riparian, instream habitat and water quality. improvement of instream habitat through hydrologic restoration, secondary channel reconnection to tributary/mainstems, and levee removal, breaching or setback to reconnect rivers to their floodplains; habitat complexity enhancement through large boulder addition, log jam creation, and wood recruitment improvement to streams through upland and riparian forest management; grazing management and the replanting of riparian areas with native vegetation to reduce stream temperature and enhance reciprocal exchanges between aquatic- terrestrial habitats; reduction of sediment delivery to streams through road maintenance/management; channel stabilization and re-aggradation through beaver restoration.	Proposals due August. 2018 RFP: http://www.nfwf.org/bbn/Pages/2018rfp.aspx	Up to $560,000 in grant funds is available. Grant awards generally range in size from $50,000 to $100,000, although grants greater than $100,000 will be considered on a case by case basis. Applicants must provide at least $1 in matching non-federal funds for every $1 of NFWF grant funds requested. Eligible non-federal matching sources can include cash, in-kind donations, and/or volunteer labor which are directly related to the project proposed for funding.	Kirstin Neff Kirstin.Neff@nfwf.org 303-222-6485	AC

Entity	Funding Program	Funding Program/ Description	Funding cycle	Total amount	Contact Information	ID
Turner Foundation	N/A	The Turner Foundation is a private, independent family foundation committed to preventing damage to the natural systems - water, air, and land. The Foundation makes grants in the areas of the environment and population and focuses on four main components: Safeguarding Habitat; Growing the Movement; Creating Solutions for Sustainable Living; and Healthy Planet, Healthy Communities.	Various	Various	www.turnerfoundation.org	AD
Rural Community Assistance Corporation	Environmental Infrastructure Loans	RCAC offers loans to finance water and waste facility projects. Projects must be located in rural areas with populations of 50,000 or less	NA	Short-term, intermediate and long term loans ranging from $50,000 – $3,000,000 depending on type of project	Karl Pennock, RDS Environmental (575) 288-6232 https://www.rcac.org/lending/environmental-loans/ Brochure: https://www.rcac.org/lending/environmental-loans/	AE
Rural Community Assistance Corporation	Individual Well Program	Visual well assessment to identify the potential threats to your well, including: -Potential sources of well contamination, including nearby agriculture and septic systems. -Visual in-person inspection of your well, including in- spection of proper sanitary seals, well cap screen and casing to reduce the risk of well water contamination. -Review of well construction relative to state standards to note any concerns. -Evaluation of water source to identify potential vulnerability.	NA	Free Assessment	https://www.rcac.org/environmental/individual-well-program/	AF

Entity	Funding Program	Funding Program/ Description	Funding cycle	Total amount	Contact Information	ID
Technical Advisory						
New Mexico Universities -UNM Water Resources Program - New Mexico Forest and Watershed Restoration Institute at Highlands University	N/A	While these institutes are not likely to provide direct funding, they could provide in-kind services such as the monitoring and technical assistance.	N/A	N/A	N/A	AG
New Mexico Soil and Water Conservation Districts (SWCDs)	N/A	Can help to provide technical assistance, particularly to private landowners needing help with implementing agricultural best management practices. The Cimarron Watershed is located within the jurisdiction of the Colfax SWCD.	N/A	N/A	N/A	AH
River Network	N/A	River Network works to protect and restore America's rivers by building the capacity of grassroots organizations and acquiring threatened riverlands. River Network offers publications, fundraising tips, technical assistance and resources, and opportunities to network with other groups across the country. River Network's Resource Library provides tools on how to raise more money, build stronger organizations, and protect rivers and their watersheds.	N/A	N/A	River Network P.O. Box 21387 Boulder, Colorado 80308 Phone: (303) 736-2724 Email: info@rivernetwork.org	AI

Entity	Funding Program	Funding Program/ Description	Funding cycle	Total amount	Contact Information	ID
Southwest Environmental Finance Center (funded by the EPA)	N/A	The primary purpose of the SW EFC is to assist state, local, tribal governments and the regulated private sector in meeting environmental infrastructure needs and achieving regulatory compliance through state and local capacity building and technical information transfer. Our goal is to build the internal capacity of the entities we assist so that they may remain in compliance and manage and finance their environmental infrastructure over the long-term. -Program focus is in water, especially drinking water. Major programs include: small system managerial and financial capacity training and technical assistance; tribal drinking water technical, managerial, and financial capacity assistance (including operator training and certification, sanitary surveys, monitoring, and training); asset management training and technical assistance; water loss auditing; and WaterCARE, a new initiative from EPA.	N/A	N/A	Information at: http://southwestefc.unm.edu/who-we-are/	AJ
William and Flora Hewlett Foundation	N/A	The William and Flora Hewlett Foundation makes grants to address the most serious social and environmental problems facing society. The Foundation places a high value on sustaining and improving institutions that make positive contributions to society. One of the goals of the Environment Program is to save the great ecosystems of the North American West.	Various	Various	Website: http://www.hewlett.org/Programs/Environment/	AK

APPENDIX D – SUPPORTING LITERATURE, MANUALS, AND GUIDELINES

Useful Information Sources for Project Implementation

After Wildfire- A Guide for New Mexico Communities

Available at: http://www.emnrd.state.nm.us/SFD/Publications/documents/AfterWildfireguide.pdf

This document is a comprehensive guide created by the ACOE, USFS, Silver Jackets and NMSF to help communities organize and respond to wildfire and subsequent flooding. The guide contains safety information, flood information, state and federal agency resources, ways to engage communities, and financial and funding tips for communities and families. The supporting website www.afterwildfirenm.org provides updated information for communities and individuals.

After Fire: Toolkit for the Southwest

Available at: https://postfiresw.info/

This website contains numerous pages of information on post-fire effects, management of post-fire flood and erosion, and information on the science of post-fire flood and erosion. The site is designed to serve managers, landowners, or communities. In addition the site houses a library of scientific literature relating to post-fire effects and hazards.

USGS Post Fire Debris Flow Assessment

Available at: https://landslides.usgs.gov/hazards/postfire_debrisflow/

The USGS conducts post-fire debris-flow hazard assessments for select fires in the western United States. The agency uses geospatial data related to basin morphometry, burn severity, soil properties, and rainfall characteristics to estimate the probability and volume of debris flows that may occur in response to a design storm. This data was utilized by SWCA hydrologists in their work. The Ute Park Fire was one of the select fires that USGS provided this analysis for. The data had been uploaded to the NASA RECOVER site: http://giscenter.isu.edu/research/Techpg/nasa_RECOVER/index.htm and the data was accessed by the SWCA Team through that outlet.

The map product displays estimates of the likelihood of debris flow (in %), potential volume of debris flow (in m^3), and combined relative debris flow hazard. These predictions are made at the scale of the drainage basin, and at the scale of the individual stream segment. Estimates of probability, volume, and combined hazard are based upon a design storm with a peak 15-minute rainfall intensity of 24 millimeters per hour (mm/h). Predictions may be viewed interactively by clicking on the button at the top right corner of the map displayed above. A "read me" is provided with metadata information. https://landslides.usgs.gov/static/landslides-realtime/fires/20180531_utepark/PFDFEstimates_README.pdf

Interagency Burned Area Emergency Response Guidebook (2006)

Available at:
https://www.nps.gov/archeology/npsGuide/fire/docs/18%20Interagency%20BAER%20Handbook.pdf

The purpose of the Interagency Burned Area Emergency Response Guidebook (Guidebook) is to provide general operational guidance for Department of Agriculture and the Department of the Interior emergency stabilization activities after a wildfire. In conjunction with Departmental and agency policy, it is designed to provide agency administrators and emergency stabilization specialists with sufficient information to:

- Understand emergency stabilization policy, standards, and procedures.
- Assess wildfire damage and develop a cost-effective plan or report.
- Assess and report accomplishments.

The document was used in this Ute Park Fire Damage Assessment as a guide for the planning and assessment process, however its main utility is in providing a framework for BAER work on federal lands by consolidating and providing an interagency interpretation of emergency stabilization policies, procedures, objectives, and standards where there is Departmental and agency agreement.

The Burned Area Emergency Response Treatment Catalog (BAERCAT)

Available at: https://www.fs.fed.us/t-d/pubs/pdf/BAERCAT/lo_res/06251801L.pdf

The Burned Area Emergency Response (BAER) treatments catalog presents, instructions, monitoring tools, and references that BAER assessment and implementation teams use to identify appropriate treatments in a BAER emergency. The catalog is written as an instruction manual for BAER teams and presents treatments for land, channels, roads/trails, and protection and safety.

The Phoenix Guide: A Handbook for Watershed and Community Wildland Fire Recovery

Available at: https://afterthefirewa.files.wordpress.com/2014/07/phoenix_guide.pdf

This Handbook was developed by the Jefferson Conservation District, Coalition for the Upper South Platte, the National Association of Conservation Districts and USDA Urban and Community Forestry. The Handbook was compiled to provide Conservation Districts, nonprofit groups, and communities with a step-by-step guide to use in developing a post-fire recovery and rehabilitation plan. It addresses, with examples and resource materials, issues such as who to involve in developing a plan, how to engage other interested parties, what elements to consider in assessing post-fire risks and priorities, and how to develop a mitigation or recovery plan to address those risks. The guide addresses the impacts of smoke; elements of pre-fire planning and preparedness; how to build community engagement; the recovery process immediately post-fire; longer-term community organizing; post fire restoration with practical information on flooding, debris flows, timber salvage etc.; Liability and risk management; and Grants and funding sources. The guide is very community focused and non-technical, meaning that it is accessible to a range of users.

Hydrologic Analysis of Post-Wildfire Conditions (2016)

Available at: https://directives.sc.egov.usda.gov/OpenNonWebContent.aspx?content=39877.wba

This is a technical note compiled by the Natural Resource Conservation Service that provides hydrologic guidance for analysis of burned watersheds. It discusses specific impacts of wildfire on the runoff process, with detailed information on modeling the rainfall runoff process in burned watersheds. The note documents hydrologic models and analysis techniques using five case studies of actual wildfire-burned watersheds.

The technical note is a good reference for the science that is used in this Ute Park Fire Damage Assessment and Rehabilitation Plan. It provides definitions of terms and descriptions of the methodologies used for post-fire damage assessments, including many utilized by the SWCA Team-including classification of burn severity, soil assessments, hydrological modeling, sediment and debris flow estimation as well as real world examples of the assessment process through the use of relevant case studies.

Post Fire Disaster Publications from NRCS

Available at:
https://www.nrcs.usda.gov/wps/portal/nrcs/detail/ca/newsroom/features/?cid=nrcseprd1289661

These are a series of publications developed by the NRCS that provide detailed guidelines for the implementation of rehabilitation measures for post-fire recovery. Fact sheets are available for implementing concrete barrier walls; contour sandbags; dike; diversion; erosion control mats; hand raking; hazard tree removal; hillside home drainage; hydro-mulching; log erosion barriers; sandbag barrier; and seeding.

Wildfire Restoration Handbook

Available at:
https://www.dropbox.com/s/256mwsb3dn86kq3/Fire%20Restoration%20Handbook.pdf?dl=0

This handbook was developed by the Coalition for the Upper South Platte, Volunteers for Outdoor Colorado and the Rocky Mountain Field Institute. The handbook provides "how-to" instructions for applying various post-fire restoration methods that can be applied in western forested watersheds. Projects include seeding, sediment control wattles, erosion blankets, log-erosion barriers, logfalls, log cross vanes, reinforced rock berms and log check dams.

National Weather Service Post Wildfire Flash Flood and Debris Flow Guide

Available at: https://www.wrh.noaa.gov/lox/hydrology/files/DebrisFlowSurvivalGuide.pdf

This guide developed by the National Weather Service is a comprehensive guide on what to do before, during, and after floods that could potentially follow recent wildfires. The guide describes the types of flooding and debris flows that could occur after wildfire, and gives tips on how to prepare for a flood event, it discusses weather warnings and how to monitor for potentially dangerous conditions, it provides emergency check lists, it describes what to do during a flood and evacuation and then what to do after a flood, including handling insurance.

Evaluating the Effectiveness of Postfire Rehabilitation Treatments

Available at: https://www.fs.fed.us/psw/publications/4403/Evaluating.pdf

This General Technical Report assesses the effectiveness of a range of common post-fire rehabilitation techniques in order to document lessons learned. The document also includes a literature review of post-fire effects to soils, hydrology and vegetation. The document can be used by landowners to assist them in making an informed decision regarding rehabilitation techniques that would be the most cost-effective and have the greatest potential for success.

Post-Fire Treatment Effectiveness for Hillslope Stabilization

Available at: https://www.firescience.gov/projects/08-2-1-10/project/08-2-1-10_rmrs_gtr240.pdf

This General Technical Report assesses the effectiveness of hillslope stabilization treatments in order to document lessons learned. The document focuses on erosion barrier treatments, mulch treatments and chemical soil surface treatments. The document can be used by landowners to assist them in making an informed decision regarding rehabilitation techniques that would be the most cost-effective and have the greatest potential for success.

APPENDIX E – COMPOSITE BURN INDEX FORM

The Composite Burn Index was used to ground truth the Soil Burn Severity Map. The following is an example of a Composite Burn Index Field Form, showing the various strata that are assessed for the degree of burn severity.

FIREMON LA Form

BURN SEVERITY -- COMPOSITE BURN INDEX (BI)

PD - Abridged	Examiners:			Fire Name:	
Registration Code		Project Code		Plot Number	
Field Date mmddyyyy	/ /	Fire Date mmyyyy	/		
Plot Aspect		Plot % Slope		UTM Zone	
Plot Diameter Overstory		UTM E plot center		GPS Datum	
Plot Diameter Understory		UTM N plot center		GPS Error (m)	
Number of Plot Photos		Plot Photo IDs			

BI – Long Form	% Burned 100 feet (30 m) diameter from center of plot =	Fuel Photo Series =

STRATA RATING FACTORS	**BURN SEVERITY SCALE** No Effect 0.0	Low 0.5	Low 1.0	Moderate 1.5	Moderate 2.0	High 2.5	High 3.0	**FACTOR SCORES**	
A. SUBSTRATES									
% Pre-Fire Cover: Litter – Duff – Soil/Rock –				**Pre-Fire Depth (inches): Litter – Duff – Fuel Bed –**					Σ –
Litter/Light Fuel Consumed	Unchanged	--	50% litter	--	100% litter	>80% light fuel	98% Light Fuel		
Duff	Unchanged	--	Light char	--	50% loss deep char	--	Consumed		N –
Medium Fuel, 3-8 in.	Unchanged	--	20% consumed	--	40% consumed	--	>60% loss, deep ch		
Heavy Fuel, > 8 in.	Unchanged	--	10% loss	--	25% loss, deep char	--	>40% loss, deep ch		X –
Soil & Rock Cover/Color	Unchanged	--	10% change	--	40% change	--	>80% change		
B. HERBS, LOW SHRUBS AND TREES LESS THAN 3 FEET (1 METER):									
Pre-Fire Cover =		**% Enhanced Growth =**							Σ =
% Foliage Altered (blk-brn)	Unchanged	--	30%	--	80%	95%	100% + branch loss		
Frequency % Living	100%	--	90%	--	50%	< 20%	None		N –
Colonizers	Unchanged	--	Low	--	Moderate	High-Low	Low to None		
Spp. Comp. - Rel. Abund.	Unchanged	--	Little change	--	Moderate change	--	High change		X –
C. TALL SHRUBS AND TREES 3 to 16 FEET (1 TO 5 METERS):									
Pre-Fire Cover =		**% Enhanced Growth =**							Σ –
% Foliage Altered (blk-brn)	0%	--	20%	--	60-90%	> 95%	Signifcnt branch loss		
Frequency % Living	100%	--	90%	--	30%	< 15%	< 1%		N –
% Change in Cover	Unchanged	--	15%	--	70%	90%	100%		
Spp. Comp. - Rel. Abund.	Unchanged	--	Little change	--	Moderate change	--	High Change		$\bar{X}$ –
D. INTERMEDIATE TREES (SUBCANOPY, POLE-SIZED TREES)									
Pre-Fire % Cover –		**Pre-Fire Number Living –**			**Pre-Fire Number Dead –**				Σ –
% Green (Unaltered)	100%	--	80%	--	40%	< 10%	None		
% Black (Torch)	None	--	5-20%	--	60%	> 85%	100% + branch loss		N –
% Brown (Scorch/Girdle)	None	--	5-20%	--	40-80%	< 40 or > 80%	None due to torch		
% Canopy Mortality	None	--	15%	--	60%	80%	%100		$\bar{X}$ –
Char Height	None	--	1.5 m	--	2.8 m	--	> 5 m		
Post Fire: %Girdled –		**%Felled –**			**%Tree Mortality –**				
E. BIG TREES (UPPER CANOPY, DOMINANT, CODOMINANT TREES)									
Pre-Fire % Cover –		**Pre-Fire Number Living –**			**Pre-Fire Number Dead –**				Σ =
% Green (Unaltered)	100%	--	95%	--	50%	< 10%	None		
% Black (Torch)	None	--	5-10%	--	50%	> 80%	100% + branch loss		N =
% Brown (Scorch/Girdle)	None	--	5-10%	--	30-70%	< 30 or > 70%	None due to torch		
% Canopy Mortality	None	--	10%	--	50%	70%	%100		$\bar{X}$ –
Char Height	None	--	1.8 m	--	4 m	--	> 7 m		
Post Fire: %Girdled –		**%Felled –**			**%Tree Mortality –**				

Community Notes/Comments:	**CBI = Sum of Scores / N Rated:**	**Sum of Scores**	**N Rated**	**CBI**
	Understory (A+B+C)			
	Overstory (D+E)			
	Total Plot (A+B+C+D+E)			

% Estimators: **20 m Plot:** 314 m² 1% = 1x3 m 5% = 3x5 m 10% = 5x6 m
30 m Plot: 707 m² 1% = 1x7 m (2x4 m) 5% = 5x7 m 10% = 7x10 m

After, Key and Benson 1999, USGS NRMSC, Glacier Field Station
Version 4.0 8/27/2004

Strata and Factors are defined in FIREMON Landscape Assessment, Chapter 2, and on accompanying BI "cheatsheet." www.fire.org/firemon/lc.htm

APPENDIX F – RESTORATION GUIDELINES FOR SOIL STABILIZATION

USDA NRCS 2012 Fact Sheet

NRCS
Natural Resources Conservation Service

Contour Wattles

Denver Federal Center
Building 56, Room 2604
PO Box 25426
Denver, Co 80225-0426

720-544-2810 - office
www.co.nrcs.usda.gov

What are contour wattles?

Straw Wattles, also known as fiber rolls, bio-logs, or straw tubes are man made cylinders of compressed, weed free straw (wheat or rice), 8 to 12 inches in diameter and 20 to 25 feet long. They may also be filled with other types of weed free fibers. They are encased in jute, nylon, or other photo degradable materials, and have an average weight of 35 pounds. They are installed in a shallow trench forming a continuous barrier along the contour (across the slope) to intercept water running down a slope.

When are contour wattles used?

Straw Wattles are used on burned slopes that have less than 30% of the original ground cover remaining and are at risk for increased erosion. They can be installed on slopes up to 50 percent. Soils can be shallow, but not less than about 8 inches. Straw Wattles increase infiltration, add roughness, reduce erosion, and help retain eroded soil on the slope. Straw Wattles should be effective for a period of one to two years, providing short term protection on slopes where permanent vegetation will be established to provide long term erosion control. Contour Straw Wattles accomplish the same treatment as Log Terraces, but require less skilled labor to install and can be placed on the slope more effectively. Straw wattles should not be placed across drainage swales and channels with more than 2 acres of contributing drainage area because they are not sturdy enough to resist the forces of concentrated flows.

What materials are needed?

- 9 -12 inch diameter tubes, 10-30 feet long.
- 5 - 1x2 or 2x2 wooden stakes, 18 - 24 inches long per wattle.
- Hand tools -shovels, polaskis, & stake hammer
- Small machines for plowing trenches on 30% or flatter slopes.

How are contour wattles installed?

- Layout a contour line on the slope with a hand level and wire flags.
- Dig a shallow depression (about 3 to 5 inches deep) and lay the wattle into it.
- Drive a 1x2 or 2x2 wooden stake through the center of the wattle at least 6 inches into the ground, stopping about two inches above the wattle.
- Put 5 stakes in each wattle, installing them end to end in the trench
- Seat the wattle with foot tamped backfill on the upstream side such that water flowing down the slope will not run under it.

Helping People Help the Land
USDA is an equal opportunity provider and employer

USDA NRCS 2012 Fact Sheet - contour wattles

How many wattles are required?

The horizontal spacing of wattles on the slope is based on normal rainfall intensity, slope steepness, soil characteristics, and the extent of surface cover remaining after the fire. Figure 1 depicts the placement straw wattles on the slope. Table 1 shows recommended wattle spacing.

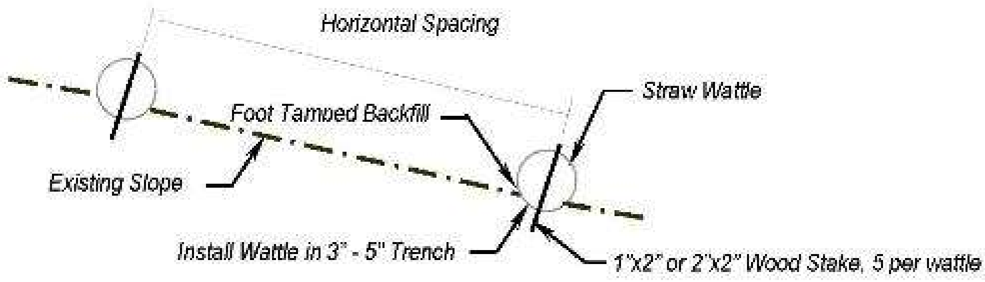

FIGURE 1 - Typical straw wattle installation

Burn severity	Low Intensity		Moderate Intensity		Severe Intensity	
land slope (percent)	**Spacing (feet)**	**# Wattles (feet/acre)**	**Spacing (feet)**	**#Wattles (feet/acre)**	**Spacing (feet)**	**#Wattle (feet/acres)**
5 - 10%	200	218	120	363	90	484
10 - 20%	120	363	60	726	40	1089
20 - 50%	60	726	30	1452	20	2178
> 50%	40	1089	20	2178	20	2178

TABLE 1 - Recommended spacing for contour wattles

NOTE: After a fire many trees are weakened from burning around the ase of the trunk. The trees can fall over or blow down without warning. Shallow rooted trees can also fall. Therefore b extremely aler when around burned trees.

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Assessment Team Considerations for Emergency Stabilization

Primary Treatment Use

Grade stabilizers are designed to prevent channel incising and downcutting. Grade stabilizers provide grade control to systems that may become destabilized from increased storm runoff and velocities.

Description

Grade stabilizers are constructed from various materials, including logs, rocks, and wood. BAER assessment teams may recommend this treatment in areas where the loss of soil cover and increased runoff would result in channel downcutting. If grade stabilizers are proposed as an emergency treatment, a hydrologist familiar with their design, implementation, and effectiveness should design them to meet the particular site specifications.

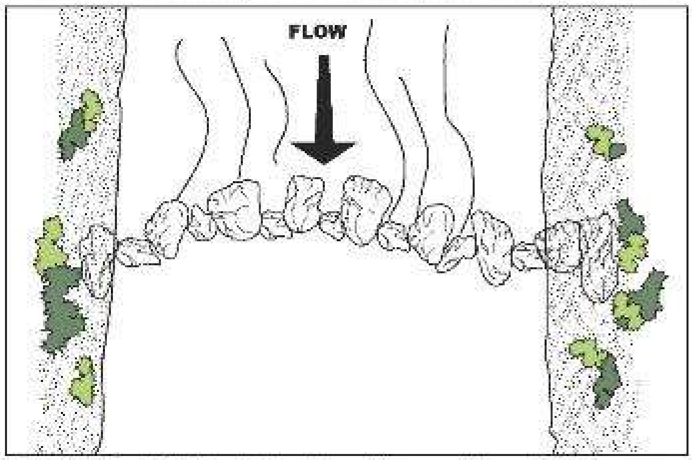

Figure 57—Grade stabilizer is placed at grade to prevent channel incision.

Purpose of Treatment

Grade stabilizers maintain channel gradient and reduce channel scouring or downcutting from increased overland runoff.

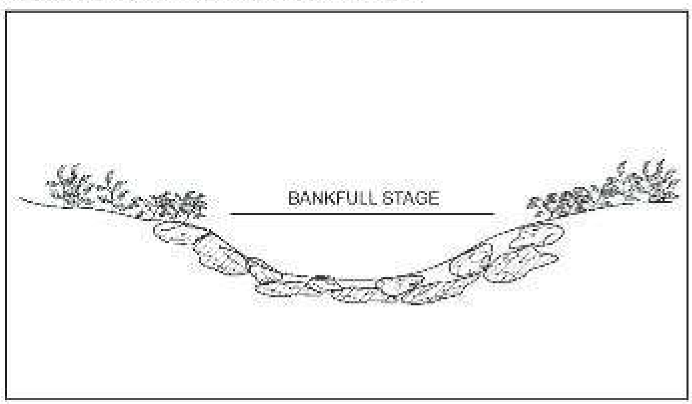

Figure 58—Bankfull view of grade stabilizer.

Chapter 3 Channel Treatments

GRADE STABILIZERS

Emergency Stabilization Objective

Objectives are to reduce water quality deterioration and establish grade control in seasonal channels.

Suitable Sites

This treatment is intended for application in one or more of the following situations:

- Downstream beneficial uses are high.
- Channel indicators of instability exist.
- Watershed has high percentage burn throughout.
- Soil cover loss and woody debris.
- Presence of persistent hydrophobic condition in watershed.
- Seasonal channels with low to moderate flows.
- Channel gradient less than 6 percent.

Cost

Limited data exists on this treatment because it is seldom used. Costs range from $250 to $4,000 per structure depending on materials and installation method.

Cost factors include the following variables:

- Material available.
- Access to sites.
- Availability of skilled workforce.
- Mechanized equipment use (backhoe/excavator).

Treatment Effectiveness

Little quantitative data is available on grade-stabilizer effectiveness as a BAER treatment. Data collected on BAER treatment effectiveness (Robichaud 2000) found no evidence that grade stabilizers were effective in stabilizing the channel gradient.

In some cases, scouring and downcutting of seasonal channels has occurred after wildfires, but our ability to predict where downcutting may occur is limited. Much of the downcutting that does occur could result from short-duration stormcells over a particular drainage that can be missed easily during the BAER assessment phase.

Occasionally, assessment teams recommend grade stabilizers. This treatment may be most effective for areas of low or moderate flows.

Project Design and Implementation Team Information

Design

After the BAER assessment team has designated potential treatment areas, review these field sites with the hydrologist to ensure suitability. Key design considerations include channel gradient, morphology and stability, adjacent hillslope conditions (soil burn severity), and available materials. Obtain any needed State or Federal streambank alteration permits prior to implementation.

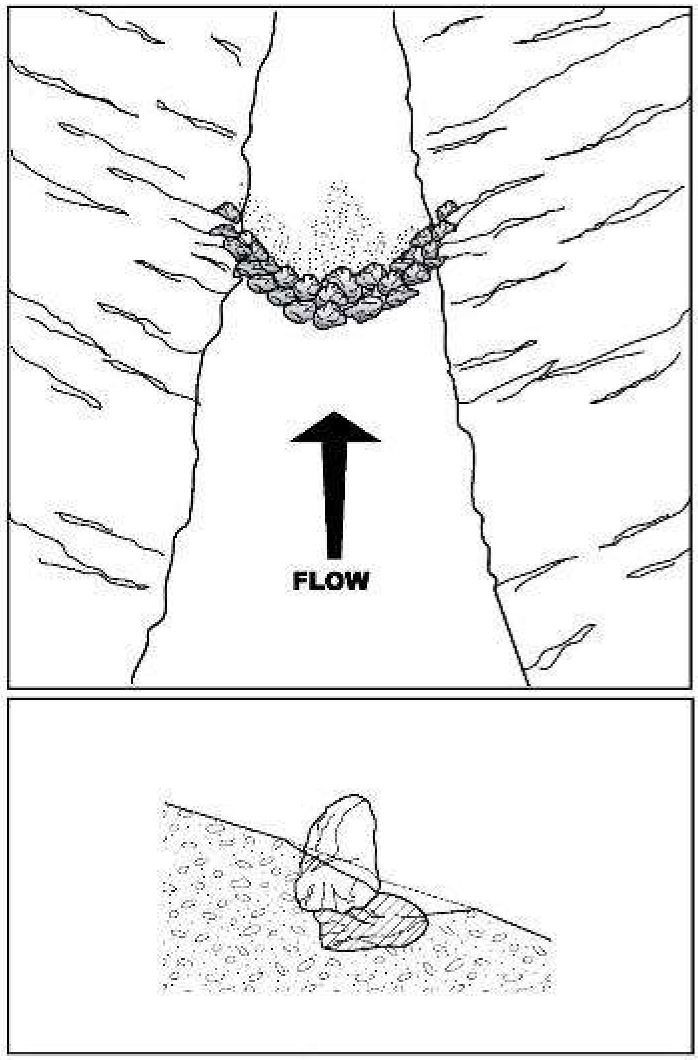

Figure 59—Stream grade can be adjusted and maintained by careful placement of boulders.

Chapter 3 Channel Treatments

GRADE STABILIZERS

Construction Specifications

Proper design and planning is required when implementing a treatment. Each rock- or log-grade stabilizer will vary depending on the site but basic requirements include:

1. Identify each treatment area by staking, flagging, and marking GPS coordinates.
2. Estimate the size and amount of material required for each structure.
   a. If using rock for the structure, ensure it is large enough to withstand the erosive force of the stream channel.
   b. If using wood or logs, estimate the width of the channel for the targeted high flows to ensure the structure is not outflanked with higher flows.
3. Construct the structure at grade, which requires excavation, depending on the materials used.
4. Spread excavated material on the slopes and/or use it to fill around the rocks.
5. Inspect and monitor the structures for any signs of erosion after the first storm event.

Tools/Equipment

Tools will vary depending on the type of material used.

- Chain saws for use on wood and log structures.
- Backhoes or excavators for placing rock structures.

Safety

Grade stabilizers are safely implemented when hazards are identified and mitigated. Review and update the JHA daily to avoid injuries. Include the following items in the JHA.

- Hazard trees and snags within treatment areas.
- Work around heavy equipment.
- Rocks or logs on site.
- Chain saw use.
- Road access to the site.

Treatment Monitoring Recommendations

Implementation

- Was the treatment implemented as designed?
- Is the structure at grade?
- Is the structure long enough to avoid outflanking?
- Were State or Federal streambank permit final reports submitted?

Effectiveness

- What type of storm events did the structure receive prior to monitoring?
- Are there indications of channel downcutting? If so, are more structures needed?
- Did the structure function as designed?

Chapter 3 Channel Treatments

Assessment Team Considerations for Emergency Stabilization

Primary Treatment Use

In-channel tree felling is prescribed to maintain channel stability and provide fish habitat. In-channel tree felling replaces woody material consumed by the fire. It also is used to treat steep drainages to reduce the risk of in-channel debris flow bulking for several years after a fire (Fitzgerald, unpublished paper).

Description

In-channel tree felling involves directionally felling trees upstream so the tops of the trees are in the channel. The trees are felled at a diagonal along designated channel reaches. The trees are staggered from side to side along the stream in a herringbone design (Ruby, unpublished paper; Fitzgerald, unpublished paper).

Purpose of Treatment

In-channel tree felling traps floatable debris and suspended sediment. Over time, woody material can cause sediment deposition and channel aggradation. Large woody material dissipates stream energy, provides cover for fish, and forms rearing and resting habitats. For seasonal channels the in-channel trees serve as dams to stabilize existing prefire bed material and to trap and store post fire sediment in the short term, while providing long-term channel stability (Fitzgerald, unpublished paper).

Emergency Stabilization Objective

In-channel tree felling reduces effects to critical natural resources (sensitive aquatic species) or downstream values (water quality and or road crossings) by restoring large woody debris to the channel and dissipating stream energy.

Suitable Sites

This treatment is intended for use in one or more of the following locations (Ruby, unpublished paper):

- Areas of high-burn severity where woody material has been consumed.
- Channels where energy dissipation is necessary.
- Channels with high values at risk such as road crossings or sensitive aquatic species.
- Channels with unstable bedload and high sediment-loading potential.

Cost

Little cost data is available for this treatment. The unit cost for directional felling in the Southwest Region (R3) for FY 2000 to 2003 ranged from $3,500 to $4,000 per mile of treatment, based on approximately 100 trees felled per mile of channel.

Cost factors include the following variables:

- Number of trees designated per mile.
- Hazard associated with felling trees.
- Location of treatment area.
- Amount of large woody material available.

Treatment Effectiveness

The Shasta Trinity National Forest has reviewed the effectiveness of in-channel tree felling for 5 years. The treatment is successful when properly located in a series along the channel. Structures reduce the risk of debris flow bulking and stream channel destabilization, yet are flexible to shift as the stream channel recovers (Fitzgerald, unpublished paper).

Other effectiveness monitoring of this treatment are by visual observations identifying if the trees are still there and if sediment was trapped.

Project Design and Implementation Team

Design After the BAER assessment team has designated potential stream reaches for in-channel tree felling, review the areas in the field to ensure the sites are suitable. Key considerations are the availability of suitable trees, ability to safely implement the treatment, and channel characteristics favorable to this treatment (increased sediment load, gradient, and loss of woody material from the fire).

Construction Specifications

- Define the treatment areas by staking, GPS coordinates, or flagging.
- Candidate trees are dead and size class is representative of the stream reach.

For perennial streams:

- Leave felled trees in one piece with the top attached.
- Space 2 trees per 50 to 100 feet of channel, with 1 tree on each side of the channel for approximately 106 to 212 trees per mile.
- Fell two trees from each side of the channel on top of each other to improve stability.
- Fell trees such that the top quarter to half of the tree is within the high-water level for that channel (Ruby, unpublished paper).

For seasonal channels:

- Fell the primary tree across the channel to "plug" the channel.
- Buck the primary tree so the log touches the channel bottom.
- Fell secondary trees to support the primary tree.
- Use trees large enough to hold the expected runoff and debris load (Fitzgerald, unpublished paper).

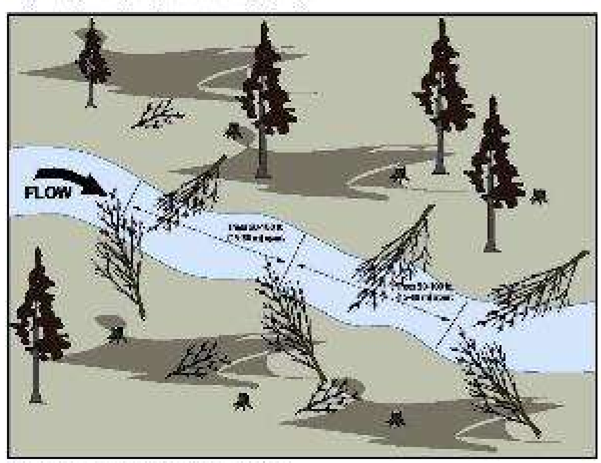

Figure 56—Directional tree felling.

Tools/Equipment

Tools necessary for implementing in-channel felling include chain saws and PPE.

Safety

In-channel tree felling is implemented safely when hazards are identified and mitigated. Review and update the JHA daily to avoid injuries. Include the following in the JHA.

- Work in and around streams with unstable footing.
- Muscle and back strain from chain saw operation.
- Hazards associated with tree felling of potentially unstable trees.

Treatment Monitoring Recommendations

Implementation

- Was the treatment implemented as designed?
- Were guidelines followed regarding the spacing, diagonal placement, and percentage of the tree within the high water level?
- How many trees per acre were placed in the channel?

Effectiveness

- Did the woody material trap sediment?
- Did the woody material protect identified downstream values (culvert or aquatic habitat)?
- Were the in-channel trees tested at the time of review according to the design storm parameters?

The following tool was developed by hydrologists Bob Blecker and Terry Benoit in 1985 during the Gorda-Rat fire. This dichotomous key modified an earlier debris stability key by Bilby.
Review of channels and literature determined that firmly anchored log jams plus large logs should remain in the channel for channel stability, fish habitat, and to stabilize instream bed material.

Stream Channel Debris Removal Key and Guidelines

Debris removal key (use as a dichotomous key starting with couplet 1)

1). a) Debris anchored or buried in the streambed or bank at one or both ends or along the upstream face – LEAVE
b) Debris not anchored – Go to 2

2). a) Debris longer than 30 feet – LEAVE
b) Debris shorter than 30 feet – Go to 3.

3). a) Debris greater than 18 inches in diameter – Go to 4.
b) Debris less than 18 inches in diameter – Go to 5.

4). a) Debris longer than 15 feet – LEAVE
b) Debris shorter than 15 feet – Go to 5.

5). a) Debris braced on downstream side by boulders, bedrock outcrops, or stable pieces of debris – LEAVE
b) Debris not braced on downstream side – REMOVE.

Assessment Team Considerations for Emergency Stabilization

Primary Treatment Use

Log erosion barriers (LEBs) are used in timbered areas with moderate- and high-burn severity where hillslope erosion rates are increased significantly from the fire.

Figure 21—High-burn severity areas on the Santa Fe National Forest with available trees that are candidate sites for contour felled LEBs.

Description

LEBs (contour felled logs, log terraces, or terracettes) are logs placed in a shallow trench on the contour. LEBs trap sediment if laid in a bricklayer pattern on the hillslope. The potential volume of sediment stored is dependent on slope, size, and length of the felled trees, and proper implementation. LEBs with soil and berms trap more sediment.

Chapter 2 Land Treatments

LOG EROSION BARRIERS

Purpose of Treatment

LEBs reduce erosion by shortening slope length, providing surface roughness, improving infiltration, and trapping sediment (Clifford, unpublished paper).

Figure 22—Contour felled LEB held in place with existing tree and stump.

Emergency Stabilization Objective

LEBs reduce hillslope erosion and adverse effects to identified values at risk (ecological integrity and water quality).

Suitable Sites

Use this treatment in one or more of these locations:

- Hillslopes with high- and moderate-burn severity.
- Slopes between 25 and 60 percent.
- Water repellent soils are present.
- Soils with high erosion-hazard ratings.
- Watersheds with high values at risk.

Cost

LEBs vary in price based on cost factors. LEB-treatment implementation costs summarized by the Southwestern Region (R3) from FY 2000 to 2003 ranged from $420 to $1,200 per acre.

Cost factor variables include:

- Treatment-area terrain.
- Site access (vehicle or helicopter).
- Number of logs placed per acre.
- Crew knowledge and experience.

Treatment Effectiveness

LEBs were the northwest's second most used treatment from the 1970s to the 1990s (Robichaud 2000). However, with cheaper and more effective hillslope treatments, such as helimulching, the use of LEBs has decreased.

Quantitative studies on the sediment-trapping efficiency of LEBs ranged from 6.7 cubic yards per acre to 72 cubic yards per acre with a high density of logs. Research in southern California found soil depths and soil water-holding capacity dictated LEB effectiveness (Wohlegemuth 2001).

Treatment Monitoring Recommendations

Six paired watershed sites from throughout the Western United States are being monitored for determining effectiveness of contour-felled logs. The storage capacity of each log was determined by calculating storage volume from onsite measurements. Volumes were calculated using the average depths and lengths then discounted for poor ground contact and slope placement. There were an average of 90 logs ha^{-1}. Average initial individual log storage was 0.38 m^3. An ocular estimate for log soil contact was also made.

Findings show the effectiveness of contour felled logs is dependent on rainfall intensity. Observations from numerous rainfall events at these six paired watershed sites indicate that the logs are more effective at trapping sediment if the 10-minute rainfall intensity is low (less than 30 millimeters per hour). With high intensity rainfall (10-minute rainfall intensity greater than 50 millimeters per hour), trap efficiency declines to less than 60 percent, which also decreases by 10 to 15 percent with each successive rain events. Soil end berms increase the storage capacity by about 12 to 15 percent, thus end berms improve their performance. (Robichaud, personal communication)

Measurement of over 3,000 logs suggests several causes for the observed compromises in effectiveness. Some of these factors can be controlled by improved installation strategies and other factors are inherent from settling and downslope runoff. Some observations include:

- 20 percent of the logs were not placed within 5 percent of the hillslope contour.
- 5 percent of the logs rolled due to stake failure.
- 15 percent of the soil end berms failed due to inadequate height and washout caused by runoff.
- 30 percent of the logs were not backfilled with soil to prevent runoff from undermining the log.

BAER implementation teams have reported the following problems with LEBs, which can be avoided with training and implementation monitoring. Common reasons for treatment ineffectiveness include:

- Trees improperly bedded caused runoff and erosion under the log.
- Trees not placed on the contour concentrated runoff and erosion at the ends of the log.
- LEB density (logs per acre) was insufficient for the slope and burn severity.
- LEBs placed on slopes greater than 60 percent.
- Areas with rocks prevented proper installation and accelerated erosion.
- Limbs left untrimmed prevented ground contact and resulted in erosion.
- Crew training was inadequate and resulted in poor implementation.
- Inspection or implementation monitoring was infrequent.

Figure 23—Contour felled LEBs 2 years after treatment.

Figure 24—Contour felled LEB 2 years later that has not trapped any sediment.

Figure 25—Area initially treated with LEBs, but secondary treatment of straw mulch is added to reduce erosion.

Project Design and Implementation Team Information

Design

After the BAER assessment team has designated potential treatment areas, review the field sites to ensure suitability. Key design considerations include standing dead-tree-diameter (6 to 12 inches diameter breast height), site accessibility, and safety. Larger tree diameters can trap and store more sediment but can be unwieldy.

LEBs are used in high-burn severity areas. Review the entire treatment polygon and flag rocky areas, low-burn severity areas, and slopes of more than 60 percent. For slopes less than 20 percent, evaluate the need for LEBs with a BAER team member or the forest soil scientist. Have the archeologist review the area and flag areas to avoid (Ruby, unpublished paper).

Tools/Equipment

To ensure safe felling, limbing, trenching, and backfilling each log, select trees that measure 6 to 12 inches diameter breast height. Tree species include conifer, alder, birch, and aspen. Straight trees make firm contact with the soil. Logs should be 10- to 20-feet long. Longer logs are difficult to handle and place correctly.

- Chain saw with complete sharpening and repair equipment (extra chain, file).
- Hazel hoe or mattock for bedding logs.
- Single-bit axe to cut and pound stakes.
- Carpenter level to ensure that logs are on the contour.
- Stakes 12 to 18 inches long to hold logs in position.
- Tape measure.

LEB Implementation

Demonstrate the correct installation method prior to implementing LEBs. Alert the crew and inspectors on spacing for different slope classes, placing the log on the contour, bedding the log, and establishing the bricklayer pattern. Use soil end berms to improve trapping efficiency (Robichaud, personal communication). Once the demonstration is complete, assign crews and inspectors to treatment areas. (Tracy, unpublished paper)

Crews should work in teams of three with one sawyer, followed at a safe distance by two people trenching and bedding the logs. Total crew size varies depending on the treatment area. Crews should start at the top of the unit and work downslope offsetting the LEBs in a bricklayer pattern.

Installing LEBs is challenging and hazardous work. Hotshot crews are commonly used to install LEBs because of their skills and experience. Contract crews also can be used.

Designate inspectors for unit layout and implementation monitoring. The inspector ensures that LEBs meet construction specifications for spacing, alignment, density, and bedding. Inspectors can use a global positioning system (GPS) to mark treatment areas for subsequent effectiveness monitoring.

Figure 26—Contour felled LEB which has filled with sediment and then failed. Sediment trapping ability of LEBs on steep slopes is limited.

Vehicles/Aircraft

- Crew carriers can be used to access designated sites.
- Helicopter access is required occasionally for more remote locations. Ensure that appropriate flight plans and JHA are included.

Production Rates

Production rates vary with the number of LEBs placed per acre. Reducing the number of LEBs to expedite the treatment jeopardizes effectiveness.

Specifications require that logs from burned trees 15 to 20 feet in length be placed 10 feet apart on slopes more than 50 percent. For slopes less than 50 percent, trees are placed 15 feet apart. Distance on the contour between the LEBs is 10 feet. Approximately 95 trees per acre are required to meet this specification based on a 20-foot log length that would provide 1,900 linear feet per acre. An estimated 100 to 200 logs per acre at 20-foot length would be required to obtain 2,000 to 4,000 linear feet per acre (see appendix F).

The LEB installation rate for a well-trained crew is approximately 1 acre per person-day depending on spacing and linear feet per acre. Experienced crews can treat 3 or more acres per person-day. Validate production rate from recent LEB installation contracts. Be sure to compare slope, spacing, and actual linear feet installed per acre.

Method of Installation

1. Identify treatment polygons on a map and clearly mark in the field.
2. Use inspector(s) review each polygon and determine whether the area complies with the specifications. Nonwork areas such as large openings (areas where burn severity will be lower), rocky areas, and slopes more than 60 percent will be identified as bypass areas (Ruby 1995).
3. Flag the perimeter of each area with a discrete color code, marked on the ground with a wooden stake, and indexed on the stake and on a project map. Record the size of the polygon.
4. Consult with the cultural resource staff prior to starting the project. Placement of LEBs is a ground-disturbing activity and requires clearance to ensure that resources are avoided and/or protected.
5. Start installation of LEBs at the top of the treatment area (Schmidt 2003).
6. Work in teams with one sawyer safely ahead of two individuals to bed the log. Some implementation teams use larger crews with a sawyer and swamper followed by four individuals to bed the log. Team size is determined by safety and efficiency.
7. Use sawyers to delimb the log to allow for 100-percent contact with the ground.
8. Check that the log is on the contour with a hand level.
9. Dig a trench on the contour 3 to 5 inches deep depending on the size of the log to break up water repellant soils.
10. Place the log in the trench on the contour and backfill the log ensuring that there are no gaps.
11. Anchor the log with wooden stakes if needed.
12. Place limbs or branches on the slope and ends of the LEBs for surface roughness and to break up concentrated flows.
13. Use inspectors to review and approve all work when treatment within a block is complete.
14. Report daily acreages treated, with acres per person-day and costs.
15. Track acres treated per block and continue layout on planned work (Tracy, unpublished paper).

Chapter 2 Land Treatments

Safety

LEBs are a hazardous treatment. Consider all hazards and review and update the JHA daily to avoid injuries. Include the following in the JHA:

- Chain saw operation and felling trees.
- Hazard trees within treatment areas.
- Stump-holes and unstable footing.

Treatment Monitoring Recommendations

Implementation

- Was the treatment implemented as designed?
- Were specifications for spacing, logs per acre, and bypass areas implemented?
- How many linear feet per acre were implemented?

Effectiveness

- Did the LEBs trap sediment?
- Did the LEBs fill with sediment?
- Are there signs of rilling?
- Did water move under the LEB?
- Was there overtopping of the LEB?
- Was the storm event the LEBs were designed for in the burned area report (FS 2500-8)?
- Had storm events occurred at the time of effectiveness evaluation?

Figure 27—Once the LEB fills, sediment will move over or around the log. Soil berms on the sides of LEBs help hold more material behind the log.

Chapter 2 Land Treatments

Assessment Team Considerations for Emergency Stabilization

Primary Treatment Use

Fiber rolls are used in high-burn severity areas where soil erosion and water quality deterioration are at risk. Fiber rolls are used where LEBs are not practical. They are for intensive treatment of high values at risk including heritage sites.

Description

Fiber rolls, commonly called wattles, are prefabricated rolls manufactured from rice straw and wrapped in ultraviolet degradable plastic or jute netting. Fiber rolls are approximately 9 inches in diameter and up to 25 feet long. A 25-foot-long fiber roll weighs 35 pounds. Fiber rolls are designed for low-surface flows not to exceed 1 cubic foot per second. They are not for stream channels or gullies (Morris 2004).

Figure 23—Fiber roll placed across the hillslope. Not all the fiber rolls are on the contour which can accelerate erosion.

Purpose of Treatment

Fiber rolls reduce erosion by shortening the slope length to slow overland flow velocity. Fiber rolls trap sediment and provide a seedbed for vegetative recovery. If water repellent soils are present, the installation of the fiber rolls may break through the water repellent layer and can improve infiltration.

Emergency Stabilization Objective

Fiber rolls reduce erosion and may reduce adverse effects to identified values at risk (ecological integrity and water quality).

Suitable Sites

Use fiber rolls in one or more of these locations:

- Areas of high- and moderate-burn severity.
- Slopes with less than 40 percent of the original ground cover remaining.
- Slopes between 20 and 40 percent.
- Soils not less than 8 inches deep.
- Slopes with less than 25-percent surface rock.

Chapter 2 Land Treatments

Cost

Fiber rolls are expensive to implement. Costs vary by project. Fiber-roll treatment implementation costs summarized by the Southwestern Region (R3) from FY 2000 to 2003 ranged from $1,100 to $4,000 per acre.

Cost factors include:

- Distance from site to staging area.
- Access to staging area for large-vehicles.
- Experience and availability of crews to install fiber rolls.
- Placement method for fiber-rolls (helicopter or handcrews).
- Vegetation remaining.
- Requirements for fiber-roll spacing.

Treatment Effectiveness

Limited effectiveness monitoring data is available on fiber rolls. Monitoring of the 2003 Cedar fire used field observations and select photopoints to document the effectiveness.

Findings indicate the need for implementation monitoring to ensure proper location, spacing, and placement of the fiber roll. Do not place fiber rolls in drainages or turn the ends down. Fiber rolls in drainages failed and fiber rolls with the end turned down contributed to rill formation (Hubbert, unpublished paper).

Vertical spacing of fiber rolls remains highly variable. Consult manufacturer guidelines, soil-burn severity maps, and erosion-hazard ratings for slopes.

Fiber rolls can attract small rodents, which in turn attract snakes that can become trapped in the netting. The wildlife biologist can assist in determining wildlife concerns (Kuyumjian, personal communication).

Figure 29—Avoid placing the fiber rolls in drainages.

Specify that fiber rolls are certified weed free for the installation State. Other informal observations of fiber rolls (wattles) and their effectiveness are:

- Fiber rolls provide good germination of seed as compared to the rest of the slope. Breaking up slope length provided germination sites (Morris 2004).
- Fiber rolls had undercutting below the wattle where there was overtopping.

- Fiber rolls function for up to 2 years but remain for several years after filling.
- Fiber rolls are awkward to transport and are difficult to install on steep slopes.
- Fiber rolls work best when placed in a trench with complete ground contact and firm anchoring.
- Fiber rolls are expensive and labor intensive. Ensure that enough experienced crews are available to complete the work in the timeframe required (Robichaud 2000).
- Fiber rolls work well in coarse-grain soils. Tests at San Diego State University Soil Erosion Research Laboratory demonstrated that fiber rolls reduce offsite sediment delivery from bare soil by as much as 58 percent with proper installation (Earth Savers, Web site).

Inspect fiber rolls after each storm event. Fiber rolls are unsuitable in areas with high-intensity, short-duration storm events where they fill quickly with material. Check the past performance of fiber rolls in the area prior to prescribing their use. Further monitoring efforts are needed to fully identify the failure mechanisms.

Project Design and Implementation Team Information

After the BAER assessment team has designated potential treatment areas, review the field sites for suitability. Key design considerations include site accessibility, vegetation remaining, and correct spacing. Fiber rolls are delivered in large trucks and the closer the trucks can get to the site the lower the cost. In some cases, helicopters can transport the wattles to the treatment area.

Design Review the entire treatment polygon and flag rocky areas, low-burn severity areas, and slopes over 45 to 50 percent. For slopes less than 10 to 15 percent, evaluate the need for fiber rolls with a BAER team member or the forest soil scientist. Have the archeologist and wildlife biologist review the area and flag areas to avoid.

Figure 30—Fiber rolls do not reduce erosion but trap sediment on the slope. Where high values are at risk identify the emergency objective and select the treatment which best meets that objective.

Chapter 2 Land Treatments

FIBER ROLLS OR WATTLES

Construction Specifications

1. Lay out a contour line on the slope with a hand level and wire flags.
2. Dig a shallow depression 3 to 5 inches deep with a pulaski or pick and place the fiber roll in it.
3. Place excavated soil downslope of the trench.
4. Place the fiber roll and backfill the upslope length of the fiber roll with the excavated soil. Compact to prevent water from flowing under the fiber roll.
5. Turn the ends of the fiber roll upslope slightly (like a smile) to trap sediment and prevent channeling of flows.
6. Drive a 1- by 2-inch or 2- by 2-inch wooden stake through the center of the fiber roll and at least 6 inches into the ground. Stop 2 inches above the fiber roll. (Stake lengths should be 18 to 24 inches. For rocky soils, rebar has been used, but should be removed after the site is stabilized.)
7. Put four stakes in a 12-foot fiber roll, five stakes in each 20-foot fiber roll, and six stakes for 25-foot fiber roll.
8. Space (horizontal) for fiber rolls depends on normal rainfall intensity, slope steepness, soil characteristics, and the extent of surface cover remaining on the slope.
9. Place wattles 50 feet apart (872 per acre) on moderate-burn severity on slopes of 20 to 50 percent. Place wattles 20 feet apart (2,178 per acre) on high-burn severity slopes. (Natural Resource Conservation Service Web site).
10. Stagger the layout on the slope in a bricklayer pattern starting at the top of the slope with a 12- to 18-inch overlap.

Figure 31—To ensure proper installation, work with experienced crews and inspect as the fiber rolls are installed. Improper installation negates the effectiveness of this treatment.

Materials

- Contour straw wattles 8 to 12 inches in diameter and 10 to 30 feet in length.
- Wooden stakes, 6- (1 by 2 inch or 2 by 2 inch) 18 to 24 inches long per wattle.

Tools

- Shovel
- Pulaski
- Hammer
- Hand level
- Flagging

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Chapter 2 Land Treatments

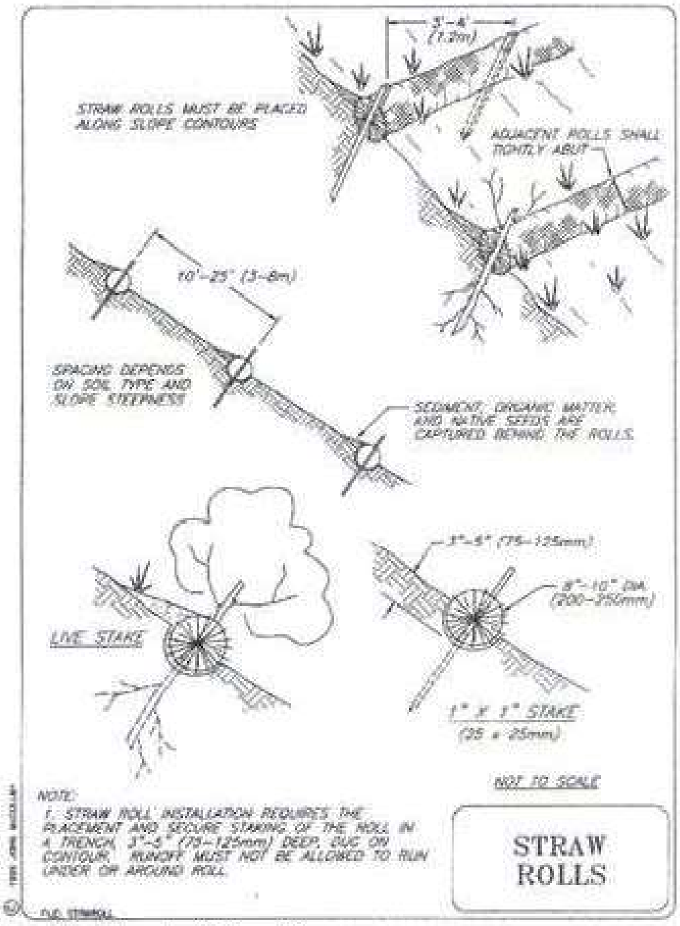

Figure 33—Fiber roll installation guide.

Safety

Fiber rolls are implemented safely when the following items are included and mitigated in the JHA.

- Aircraft-safety plan if using any aircraft to move wattles.
- Injuries from stakes, splinters, and traversing rugged ground.
- Allergies to straw.

Treatment Monitoring Recommendations

Implementation

- Was the treatment implemented as designed?
- Were specifications for spacing, location, and installation of fiber rolls implemented?
- How many linear feet per acre were installed?

Effectiveness

- Did the fiber rolls trap sediment?
- Are there indications of rilling?
- Were the fiber rolls undercut?
- Was there overtopping of the fiber roll?
- What type of storm event were fiber rolls designed for in the FS-2500-8?
- What storm events had occurred at time of effectiveness evaluation?
- Did the fiber roll trap seeds for revegetation establishment?

Chapter 2 Land Treatments

SLASH SPREADING

Assessment Team Considerations for Emergency Stabilization

Primary Treatment Use Slash spreading provides soil cover to moderate- and high-burn severity areas. The treatment is designed to reduce hillslope erosion by increasing ground cover with available onsite materials. Recent studies by Missoula Technology and Development Center (MTDC) and Rocky Mountain Research Center used onsite small diameter trees to provide effective ground cover. (Groenier, 2004)

Description Slash spreading involves felling, lopping, and scattering submerchantable trees and brush to provide soil cover.

Figure 15—Mechanized equipment can quickly produce slash for effective soil cover.

Purpose of Treatment Slash spreading reduces erosion by providing soil cover.

Emergency Stabilization Objective Slash spreading reduces erosion to prevent the unacceptable degradation of critical natural resources.

Suitable Sites This treatment is intended for use in one or more of the following locations:

- Areas of high- and moderate-burn severity.
- Areas burned but with available slash material onsite.
- Soils with high erosion-hazard ratings.

Figure 16—Completed unit with slash spread uniformly.

Chapter 2 Land Treatments

SLASH SPREADING

Cost

Cost data for slash treatments in the Southwestern Region (R3) for FY 2000 to 2003 ranged from $220 to $1,000 per acre.

Cost factors include the following variables:

- Availability of submerchantable trees or brush for slashing.
- Topography of treatment area.
- Ease of obtaining good soil contact with slash material (amount of chain saw work required).

Treatment Effectiveness

Chain saw-created slash spreading is ineffective in many areas due to the large amount of material needed for adequate soil cover. Burned areas lack enough slash for erosion control. Production rates are slow because extensive chain saw work is needed for good soil contact.

Slash spreading is used in small areas where unique resources and adequate slash are found. Slash spreading protects cultural resources from erosion and can camouflage the sites.

New studies reveal additional opportunities to provide erosion control by engineered wood products or through mastication and onsite shredding of small diameter trees.

Engineered wood mulch was tested for use on burned areas. This type of product consists of a blend of sliced wood strands that provide erosion control over two or more seasons. Rainfall simulation studies completed by Rocky Mountain Research Station indicate the effectiveness of engineered wood mulch. BAER teams have had difficulty procuring the material which sells for about $60 per 600-pound bale or $6.75 per 50-pound bale (siwdsystems, Web site).

Use of track-mounted shredders on the Borrego fire and the Clearwater National Forest demonstrate opportunities for shredding to reduce erosion. Track-mounted machines can shred trees 6 to 8 inches in diameter and provide "weed free" erosion control (Groenier, 2004). Equipment varies but generally enables an operator to treat an area within a 20-foot radius from a single position. Track-mounted machines tested in New Mexico exerted less than 4 pounds per square inch of ground pressure (Armstrong, unpublished paper).

Figure 17—Closeup of the slash material generated with heavy equipment.

The mulching head is capable of grinding the tree into chips or coarse pieces. Other equipment combinations include an excavator with shredder and a centrifuge blower to distribute the wood. MTDC is conducting studies to review alternative collection and distribution systems including aerial applications to place the material within the treatment unit.

Project Design and Implementation Team Information

Design

Review the treatment areas in the field to ensure that sites are suitable. Identify any hazards that may have to be removed or avoided prior to implementing treatment. Obtain heritage-resource clearance if heavy equipment is used to implement the treatment.

Tools/Equipment

Slash spreading commonly is implemented with a hotshot crew or a 20-person handcrew with chain saws. Mechanized equipment (hydro-ax) masticates trees into smaller pieces and provides more uniform cover (Kuyumjian, personal communication).

Safety

Slash spreading can be hazardous. Consider all hazards and update the JHA daily to avoid injuries. Include the following in the JHA.

- Hazard associated with tree felling and chain saw operation.
- Hazards associated with heavy equipment using sharp, high-speed moving parts.
- Stump-holes and unstable footing.

Treatment Monitoring Recommendations

Implementation

- Was the treatment implemented as designed?
- Were guidelines followed regarding effective soil coverage?

Effectiveness

- Did the slash spreading trap sediment?
- Did the slash spreading reduce erosion in the treatment area?
- Did the slash stay onsite?
- Was the percentage of soil cover known? If so, how much?
- Was the treatment tested by the design storm at the time of monitoring?

APPENDIX G – DRONE PHOTOGRAMMETRY

(Submitted digitally)