# Archie Creek Fire

Erosion Threat Assessment/Reduction Team (ETART) Extended Report

December 2020

FEMA

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# Executive Summary

This report summarizes a rapid characterization of post-fire conditions resulting from the Archie Creek Fire and identifies critical values potentially at risk from threats commonly associated with burned areas. In addition, the ETART assessment of drinking water threats from the Archie Creek Fire and other fires are captured in the ETART Water Quality/Drinking Water Supply Resource Report. The area of interest for this report consists of non-federal lands within and downstream of the Archie Creek Fire perimeter. Critical values include human life and safety; improved properties/assets such as roads, bridges, buildings and water systems; important natural resources (soil productivity, water quality and municipal water sources, habitats for wildlife and fish); and cultural resources. Threats that exist or are recognized to amplify in a post-fire setting include accelerated soil erosion and hillslope water runoff that results in increased sediment transport, high stream flows, floods or debris flows; landslides and rock fall; hazard trees; mobilization of hazardous materials; and expansion of invasive or noxious plants. This report does not include an assessment of water quality and water systems that provide safe, clean drinking water. Refer to the ETART Water Quality/Drinking Water Supply Resource Report for information on post-fire threats and response actions for these values.

The essential findings of this evaluation are: 1) to identify where emergency conditions exist as defined by critical values at unacceptable risk from imminent post-fire threats; and 2) to recommend emergency response actions that reduce risk or minimize impacts to critical values. In addition to the emergency response actions, the data, analysis and conclusions supporting this report can be used to develop restoration opportunities leading to long-term recovery of the fire-damaged landscape. Multiple "Specialist Reports" encompassing soils, hydrology and water quality, engineering, fish and wildlife, botany and cultural were used to complete this assessment.

The 2020 fire season in Oregon State affected lands across all jurisdictions and ownerships: tribal, federal, state, local and private. Fires on federal and tribal lands are assessed through the U.S. Forest Service (USFS) Burned Area Emergency Response (BAER) or Department of Interior (DOI) Emergency Stabilization and Rehabilitation (ESR) programs. Given the size and severity of the fires' impacts to state, local and private lands throughout Oregon, the State of Oregon requested the Federal Emergency Management Agency (FEMA) form a multi-jurisdiction assessment team to assess the state, local and private lands of several fires. FEMA coordinated with Oregon Emergency Management (ODF) and Department of Forestry (ODF), National Weather Service (NWS), U.S. Army Corps of Engineers (USACE) and the USFS to staff the Erosion Threat Assessment and Reduction Team (ETART) to evaluate the fire-affected state and private lands.

The team used the USFS BAER and DOI Emergency Stabilization & Rehabilitation (ESR) assessments for several fires, which established the foundation for the ETART and allowed for comprehensive evaluation of all lands burned within the fires.

2020 Oregon ETART is comprised of personnel from Clackamas County Soil and Water Conservation District (SWCD), Lane County, Linn County, Marion County SWCD, West Multnomah SWCD, OR Department of Environmental Quality (DEQ), OR Department of Fish & Wildlife (ODFW), ODF, OR Department of Geology and Mineral Industries (DOGAMI), OR Department of Transportation (ODOT), OR Water Resources Department (OWRD), Bureau of Land Management (BLM), Environmental Protection Agency (EPA), FEMA, USFS, U.S. Geological Survey (USGS), NWS and the Natural Resources Conservation Service (NRCS). These resource specialists completed the assessments while safely managing COVID-related protections, navigating interagency data sharing barriers, operating in a hazardous post-fire field environment and working across a broad geographic area. ETART members went above and beyond the demands of their normal duties to carry out critical emergency assessments in service of local communities.

# 1. Overview

## 1.1. Burned Area Characterization

- Fire Name: Archie Creek
- State: Oregon
- Fire Number: OR-UPF-000436
- County: Douglas
- Date Fire Started: September 8, 2020
- Date Fire Contained: November 16, 2020
- Suppression Cost: $40,000,000 (estimate, ICS-209 dated 10/22/2020)

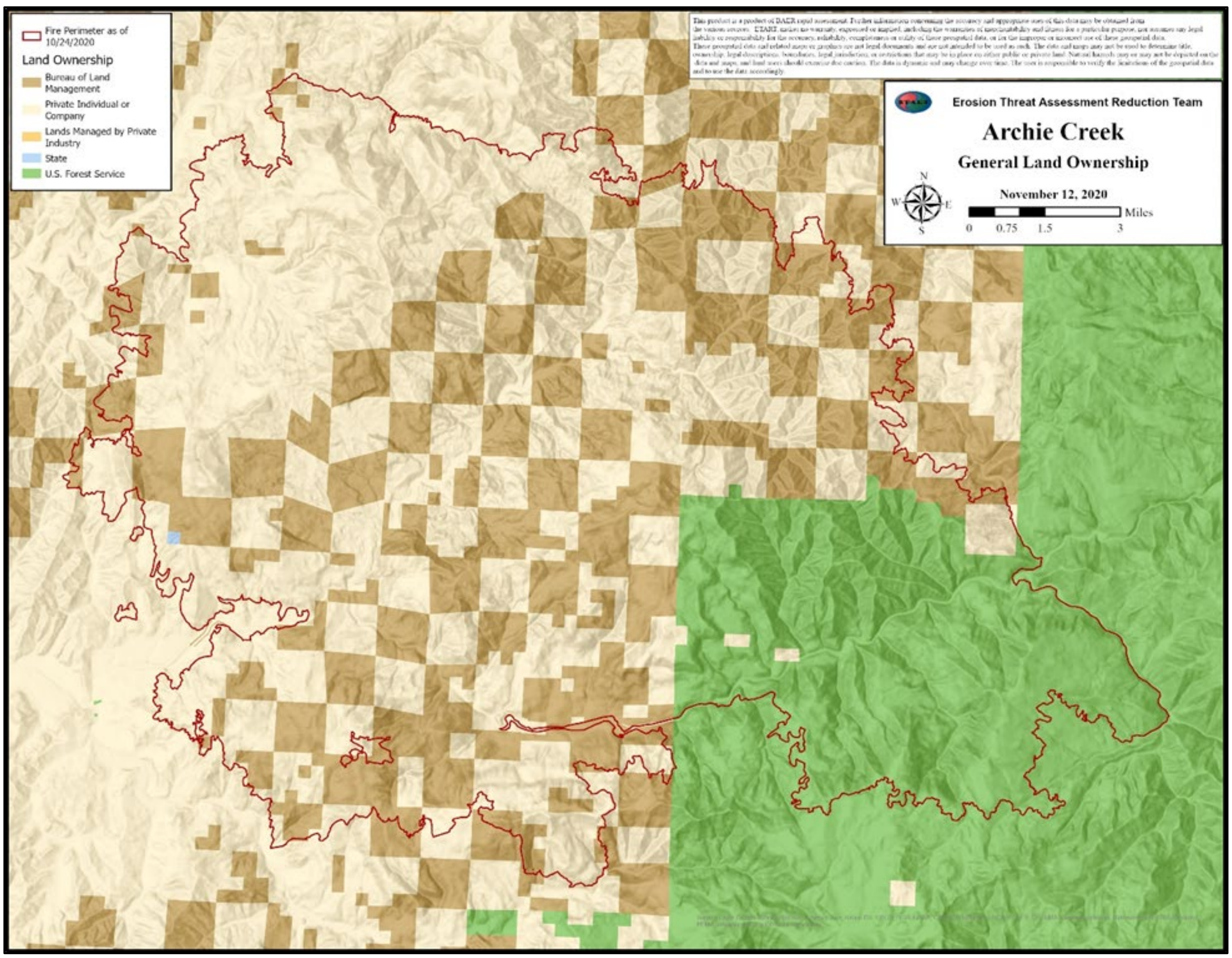


**Figure 1. Land Ownership - Archie Creek Fire**

The Archie Creek Fire was detected on September 8, 2020, east of Glide, Oregon, in the North Umpqua River drainage during a strong east wind event that passed through the area. The fire merged with the Star Mountain Fire in the Susan Creek area and burned roughly 68,000 acres in one day. On September 9th the fire progressed to 110,000 acres; 109 homes were destroyed, and nine other structures were damage or destroyed over a 2-day burning period. The fire burned across multiple land ownerships, including the Umpqua National Forest, BLM, private timber land, and through the communities of Rock Creek and Steamboat along both sides of the North Umpqua River and the Rogue-Umpqua Scenic Highway. (Figure 1 and Table 1.)

**Table 1. Archie Fire Total Acres Burned – 131,596[a] (based on post-fire analysis perimeter)**

| Ownership | Acres | Sq.Mi. | Percent |
|---|---|---|---|
| Private | 64,676 | 101 | 49% |
| State | 39 | <1 | <1% |
| Federal | 66,881 | 105 | 51% |
| **Total** | **131,596** | **206** | |

a: the burned area lies entirely within Douglas County, Oregon.

### 1.1.1. CLIMATE

The burned area is a region that experiences precipitation patterns of frontal rain/snowstorms and occasional summer convective thunderstorms. Precipitation in the area primarily occurs between October and April as multiple day frontal storms, averaging between 40 and 100 inches annually. The upper regions of the burned area are within the transient snow zone (2,000-5,000 feet elevation). The North Umpqua River gorge and its tributary valleys are below 2000 feet and within the rain zone. Late winter rain-on-snow events can result in extreme flood events. Peak flows can be much higher in the lower tributaries where rainfall and rain-on-snow events are not moderated by the storage capacity of the underlying bedrock, as is the case with streams in the High Cascades geology within the transient snow zone. Wetting rains fell over the western part of the fire area on September 18th, with some areas receiving about 0.25 inch of precipitation. Field reconnaissance reported no observations of overland flow or erosion concerns.

La Niña conditions are present in the tropical Pacific, with an approximately 85% chance of lasting through the winter. Forecasters predict this La Niña will be on the stronger side and peak November through January, with higher than normal precipitation and snowpack.

### 1.1.2. GEOLOGIC TYPES

The burned area lies within the Western Cascade province of the Oregon Cascade Range, which is characterized by older volcanic rocks, generally steep slopes, and large ancient landslide deposits. The bedrock geology is primarily comprised of Pliocene to Quaternary igneous extrusive rocks: basalt, basaltic andesite, dacite, and rhyolite. In general, the landscape shape and surficial deposits consist of unconsolidated alluvium, terrace deposits, fluvial glacial, glacial till, rockslide, landslide and debris flow deposits. Weathered rocks in this province support relatively high rates of runoff and erosion. Consequently, mass wasting processes associated with steep mountain slopes include rapidly moving, shallow-seated debris avalanches, debris slides and debris flows. Landslides have been mapped by the State of Oregon Department of Geology and Minerals Industries (DOGAMI), with these features occurring primarily in a tuff and sedimentary geology that is a minor component along the western border of the area.

### 1.1.3. DOMINANT SOILS

Dominant soils originate from andesites to basalts, as well as minor areas of weathered red breccia, highly weathered breccias, tuffs, and welded tuffs. Outcrops with exposed rocks are common throughout the area. Soils tend to be shallow to moderately deep, depth to bedrock less than 3 feet up to 8 feet. Surface soil textures range from loamy sands, sandy loams, loams and clay loams with varying amounts of gravel and rock content, generally increasing with depth. These soils are moderately well to well drained with rapid to moderate permeability and minimal water-holding (retention). One-quarter (25%) of the fire area has very steep slopes of 60 to 100 percent or more. Primary concerns on the steep slopes are the potential severe surface erosion and for shallow debris slides. Soil textures are mainly very gravelly to extremely gravelly loams and clay loams.

### 1.1.4. VEGETATION TYPES

Forested areas are primarily Douglas-fir, but with lesser components of incense cedar and western hemlock. Scattered throughout uplands are dry meadows, rock balds and steep rocky slopes dominated by Pacific madrone, Oregon white oak and various grasses. These dry meadows provide habitat for several rare and endemic species. Riparian corridors are hardwood-dominated with tree cover provided by alder and bigleaf maple, with various willow species growing along and within streams. Occasional forested wetlands are also present within riparian corridors. The western extent of the fire, both north and south of the river corridor, are comprised of a patchwork of oak woodlands and meadows used for commercial livestock grazing (cattle and sheep). Oak woodlands are Oregon white oak with an understory of poison oak, oceanspray and other drought-tolerant shrubs. Native and nonnative pasture grasses, including California oatgrass, perennial ryegrass and orchard-grass dominate meadows used for livestock grazing. Although relatively small in area, wet meadows and emergent wetlands occur throughout the burned area with a variety of species ranging from common pasture grasses to common cattail, slough sedge and smallfruit bulrush. There are several known populations of noxious weeds that have been treated with chemical herbicide for decades. These include scotch broom, Himalayan blackberry, English holly, English hawthorn, slender false brome, bull thistle, Canada thistle, St. John’s wort, meadow knapweed, tansy ragwort and medusahead.

### 1.1.5. WATERSHEDS AND STREAMS

The Archie Creek Fire burned within 17 subwatersheds, the heaviest impacted being Lower Rock Creek, East Fork Rock Creek and Susan Creek-North Umpqua (Table 2, Figure 2). The fire burned both north and south of the North Umpqua River within the area designated as a National Wild and Scenic River. There are 968 miles of streams, (255 miles perennial and 681 intermittent) within the fire perimeter, including about 17 miles of Designated Critical Habitat for Oregon Coast Coho and 18 miles of suitable occupied habitat for Coho. The North Umpqua and its tributaries are listed on Oregon DEQ's 303(d) list of impaired streams for water temperature.

**Table 1. Affected Watersheds – Archie Creek Fire (6$^{th}$ Level Hydrologic Unit Name)**

| Watershed Name | Total Acres | Acres Burned | % Burned |
|---|---|---|---|
| Lower Canton Creek | 34,601 | 7,410 | 21 |
| Lower Steamboat Creek | 33,115 | 61 | 0 |
| Panther Creek | 24,325 | 3,961 | 16 |
| Apple Creek-North Umpqua River | 23,453 | 5,515 | 24 |
| Williams Creek-North Umpqua River | 24,799 | 20,561 | 83 |
| Thunder Creek-North Unpqua River | 33,164 | 24,861 | 75 |
| Susan Creek-North Umpqua River | 33,978 | 32,068 | 94 |
| Upper Rock Creek | 47,658 | 15,548 | 33 |
| East Fork Rock Creek | 28,619 | 27,407 | 96 |
| Lower Rock Creek | 49,091 | 49,091 | 100 |
| Emile Creek | 161 | 26 | 16 |
| Middle Little River | 31 | 26 | 84 |
| Lower Little River | 15 | 13 | 87 |
| Bradley Creek-North Umpqua River | 11,352 | 8,632 | 76 |
| Headwaters Calapooya Creek | 19,428 | 5,283 | 27 |
| Hinkle Creek-Calapooya Creek | 23,497 | 11,400 | 49 |
| Gassy Creek-Calapooya Creek | 25,460 | 2,618 | 10 |
| **Total** | **412,747** | **214,481** | |

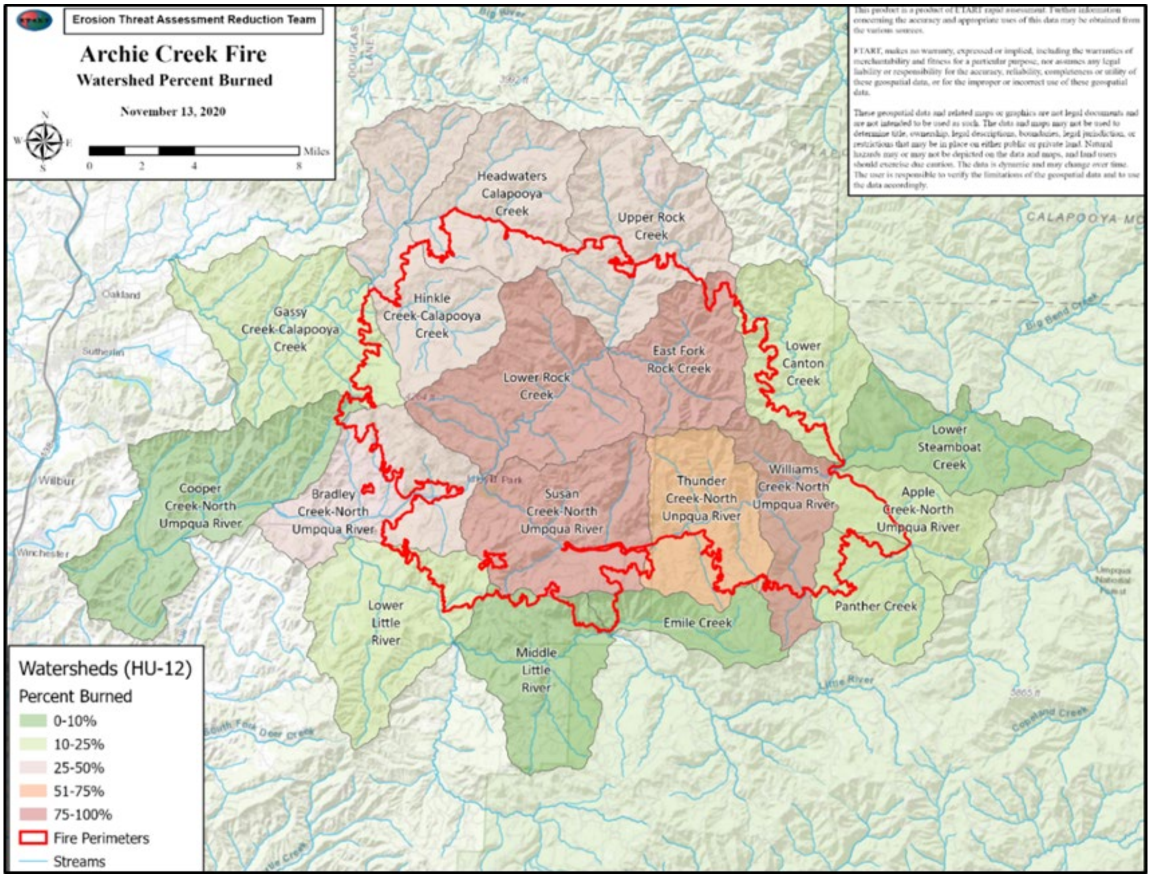


**Figure 2. Watersheds Percent Area Burned – Archie Creek Fire**

**Table 3. Road Miles by Ownership Designation within Fire Perimeter**

| Owner Designation | Miles[a] |
|---|---|
| Bureau of Land Management | 295.1 |
| County Route | 5.1 |
| Forest Service | 109.3 |
| Other State Route (e.g., State Park) | 0.8 |
| Private Route | 511.2 |
| State Highway | 16.8 |
| Unknown | 1.7 |
| **Total Miles** | **940.0** |

**Table 4. Miles of Stream within Fire Perimeter by Type**

| Stream Type | Miles by Type[b] |
|---|---|
| Perennial | 255 |
| Intermittent | 681 |
| Ephemeral | 1 |
| Other | 31 |

a: Does not account for priority travel routes below the fire perimeter that may be a “Value” or threatened by flooding or debris flows.

b: Does not account for streams below the fire perimeter that may be a “Value” as domestic or municipal source water, or for aquatic habitat.

## 1.2. Post-fire Watershed Condition

### 1.2.1. SOIL BURN SEVERITY (SBS):

The post-fire watershed conditions are mostly driven by fire behavior, which is largely a function of pre-fire fuel conditions (vegetation types, volumes, arrangement and moisture content) as influenced by weather and topography. Soil Burn Severity (SBS) is the fundamental post-fire factor for evaluating changes in soil processes and hydrologic function, which are used to evaluate watershed response, identify post-fire threats and assess the level of risk to critical values.

Prior to the ETART effort, the Forest Service produced a Soil Burn Severity (SBS) map as part of their Archie Creek BAER Assessment (Figure 3). The Forest Service SBS mapping did not field-validate soil conditions on private or state lands. The ETART soils team completed soil burn severity validation on state and private lands with on-the-ground data collection and visual observations (Table 5).

**Table 5. Soil Burn Severity (SBS) Acres.**

| Soil Burn Severity Class | All Lands | | Federal Lands | | Local Lands | | Private Lands | | State Lands | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Acres | % | Acres | % | Acres | % | Acres | % | Acres | % |
| High | 43,251 | 33% | 22,384 | 52% | 20,867 | 48% | 0 | 0 | 43,251 | 33% |
| Moderate | 57,900 | 44% | 26,535 | 46% | 31,265 | 54% | 10 | <1% | 57,900 | 44% |
| Low | 18,681 | 14% | 10,741 | 58% | 7,911 | 42% | 29 | <1% | 18,681 | 14% |
| Unburned | 11,692 | 9% | 7,178 | 61% | 4,514 | 39% | 0 | <1% | 11,692 | 9% |
| **Total** | **131,524** | | **66,838** | | **64,557** | | **39** | | **131,524** | |

Though the Archie Creek Fire is dominated by moderate and high burn severities, there was little change to the mineral soil in most instances. Soil structure was generally left intact. Roots were affected in some areas, but 100 percent root mortality was rarely observed. Water repellent soils were variable, but rarely exceeded a medium rating. However, the soils in the area are naturally disposed to erosion risk, and profound loss of vegetation and ground cover will exacerbate soil erosion.

### 1.2.2. WATER-REPELLENT SOIL (ACRES)

Water repellent soils are present across all SBS classes. Based on field assessments and knowledge of local soil types, some degree of water-repellence is expected to exist on all upland acres. Natural repellency is common in ash-influenced soils in the Cascades. When ground cover and organic soil layers are removed by fire, runoff related to naturally occurring repellency is commonly more pronounced or more efficient. In some locations it is likely longer fire residence time has exacerbated inherent water repellency by increasing areal extent and repellency class, however it is not possible to make reliable predictions without extensive, intensive data collection.

### 1.2.3. SOIL EROSION INDEX

The soil erosion index (SEI) describes the sensitivity for soil loss after disturbance removes the protective vegetation and litter cover. The SEI is primarily a function of hillslope soil processes and hydrologic function, as influenced by disturbance, such as fire, and slope. The SEI is described as "low", "moderate", "high" or "very high". Low SEI indicates soil erosion is unlikely. Moderate SEI indicates soil erosion is likely with a potential decrease in soil productivity. High SEI indicates soil erosion is very likely to decrease in soil productivity. Very high SEI indicates a high probability for soil loss and decreased soil productivity, where erosion control measures are impractical and cost prohibitive.

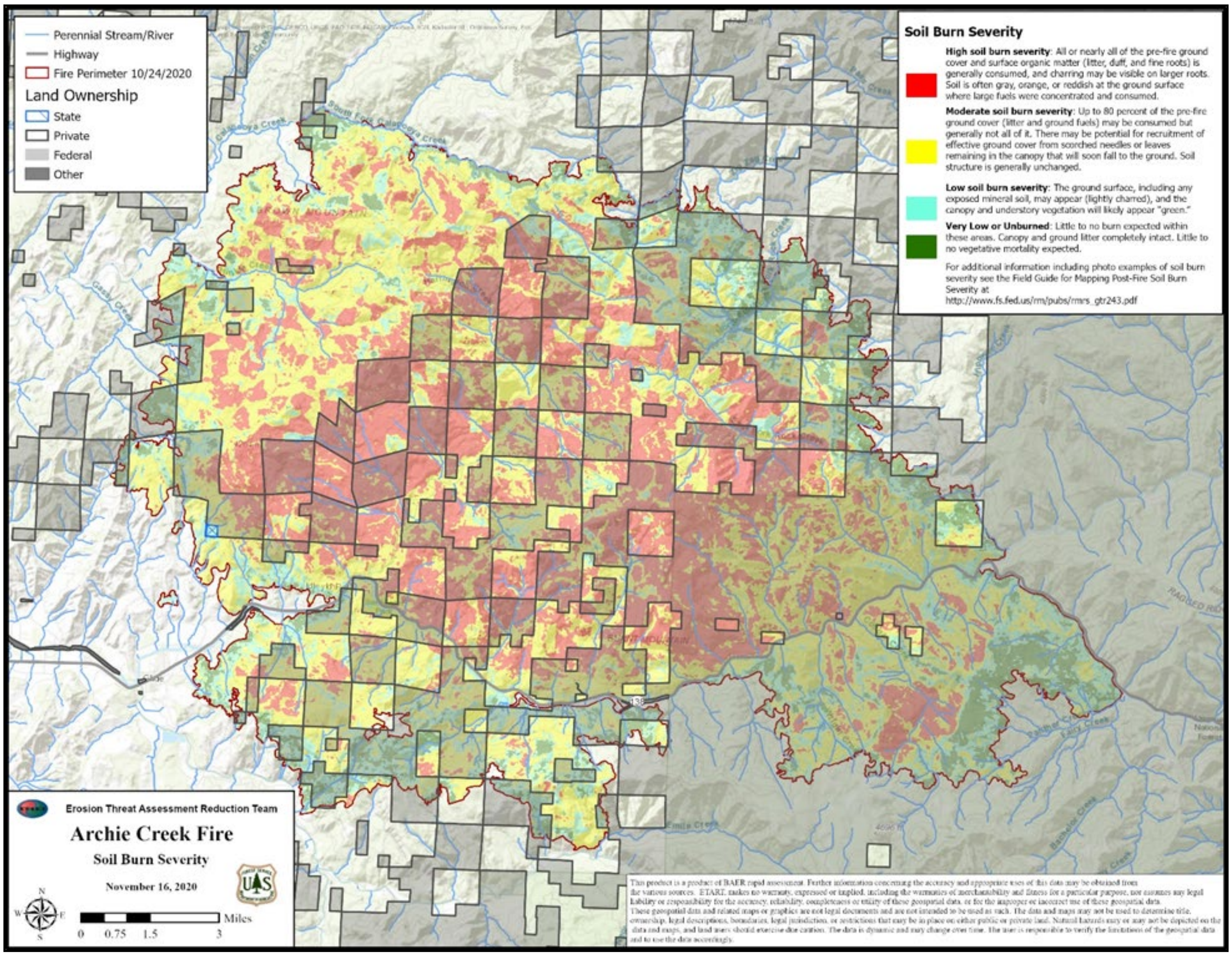


**Figure 3. Soil Burn Severity – Archie Creek Fire**

Figure 4. displays the spatial distribution and acres by SEI for the area burned by Archie Creek Fire. The matrix values in the map table represent combinations of inherent SEI with SBS. The analysis estimates 76% of the burned area has increased potential for accelerated soil erosion. The very high SEI is generally attributed to over-steepened slopes where SBS has minor influence to change soil erosion.

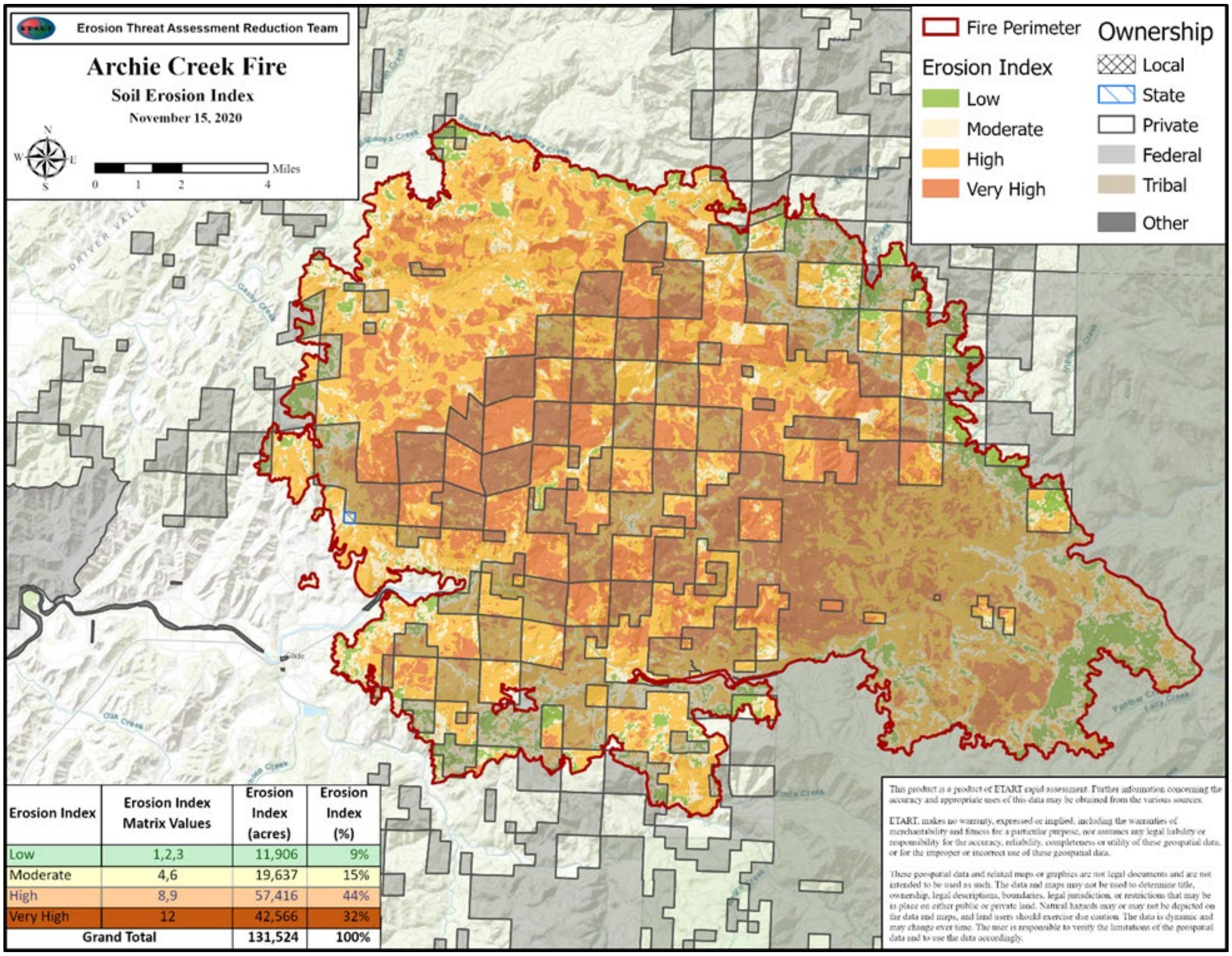


**Figure 4. Soil Erosion Index – Archie Creek Fire**

### 1.2.4. EROSION POTENTIAL

This analysis identifies hillslopes where post-fire accelerated erosion elevates the level of threat to downslope critical values. Estimates for hillslope soil loss were generated using the Water Erosion Prediction Project Cloud -Disturbed (WEPPCloud - Disturbed) Model (Robichaud and others 2019). A total of 8 drainages across 4 subwatersheds (HUC12) were evaluated. Each drainage was modeled for post-fire response using the SBS data and compared to unburned conditions. The estimated increase in soil loss per watershed unit area ranges from 0.1 to no change up to 4 tons/acre the first year after the fire, averaging about 2 tons/acre increase across the burned watersheds of interest. On average there is roughly an estimated 10-times increase in potential soil erosion post-fire over undisturbed conditions. The magnitude of increase for post-fire erosion was largest across the Rock Creek tributary near the Rock Creek Fish Hatchery, Harrington Creek, Kelly Creek and McComas Creek. with Hinkle, Beaty and Honey Creek have smaller predicted increases.

### 1.2.5. ESTIMATED VEGETATIVE RECOVERY PERIOD (YEARS)

This is the estimated period of time (years) for the burned area to develop vegetation sufficient to reduce runoff and erosion potential to essentially pre-fire conditions. Vegetation recovery varies depending on plant association group, soil type, aspect, and soil burn severity. Areas burned at low severity will generally recover within two years. Areas impacted by moderate SBS may recover the understory and shrub layers in 3-5 years. For areas having high SBS and stand-replacement fire with loss of overhead canopy from conifer tree species, ecosystem recovery will take up to 2-3 decades.

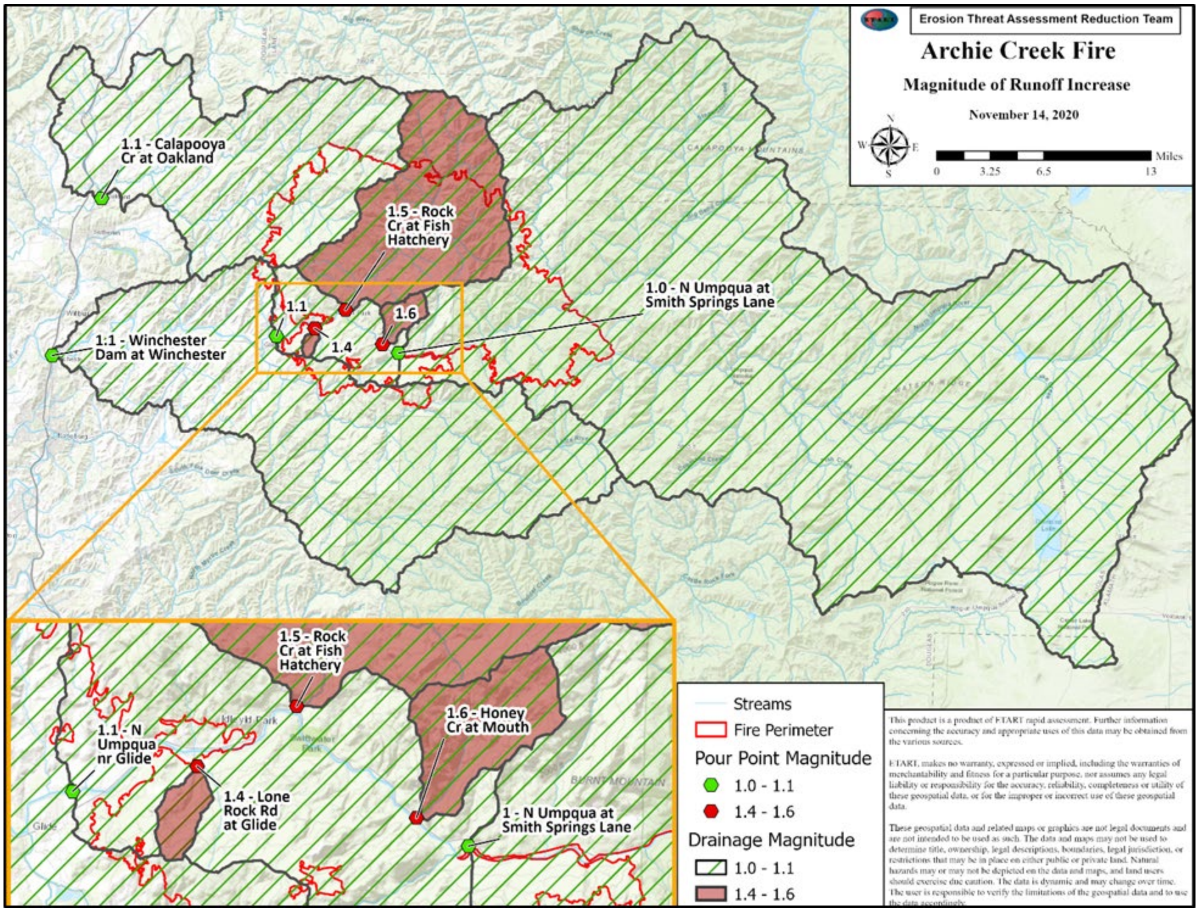

**Figure 5. Watershed Response in Runoff Magnitude Increase – Archie Creek Fire**

## 1.2.6. ESTIMATED HYDROLOGIC RESPONSE

Regional regression equations were used to estimate pre- and post-fire peak flows. The relative increase in 5-year post-fire peak flows is expected to be largest in Lone Rock Road, Rock Creek and Honey Creek basins. These drainages are predicted to be roughly 1.4 to 1.6 times greater than the pre-fire peak flow magnitude at the 5-year recurrence interval. The elevated peak flow response is due to greater percentage of area having moderate or high SBS. In contrast, the estimated increase in magnitude for post-fire peak flows in the other basins is 1.1 times the pre-fire peak flow (Figure 5). The 2020 ETART Archie Creek Hydrology Report provides the detailed analysis for post-fire hydrologic response.

These basins were created to estimate watershed characteristics, estimate post-fire response for runoff and assess the need for treatment actions. This analysis of relative stream response should only be used as a tool to better understand varying levels of risk presented by post-fire peak flows in context of downstream values. Post-fire stream response in smaller watersheds tends to be much greater than those in large watersheds. This is because of the relative volume of water it takes to show an amplified increase from pre-fire flow and the spatial scale of continuous high-severity fire patches in relation to the extent of a storm event in the Cascades.

# 2. Risk Assessment and Recommendations

The ETART resource groups identified numerous values having varying degrees and types of threats, which are listed in the ETART Archie Creek Fire Values Table. The post-fire watershed conditions determined through field assessment and data analysis were used by the ETART to validate post-fire threats and, subsequently, using the risk assessment matrix assign each specific value a level of “Risk” defined by the probability of damage or loss coupled with the magnitude of consequences (Figure 6). A burned area emergency exists when a value has a risk rating of “very high” or “high” for all values and an “intermediate” risk for life and safety. These values are prioritized for emergency response or stabilization actions known to mitigate potential threats or minimize expected damage.

| Probability of Damage or Loss | Magnitude of Consequences | | |
|---|---|---|---|
| | Major | Moderate | Minor |
| Very Likely | Very High Risk | Very High Risk | Low Risk |
| Likely | Very High Risk | High Risk | Low Risk |
| Possible | High Risk | Intermediate Risk | Low Risk |
| Unlikely | Intermediate Risk | Low Risk | Very Low Risk |

**Figure 6. Risk Matrix**

## 2.1. Human Life and Safety Summary

### 2.1.1. HAZARD TREES

Very High risk to **motorists along roadways, people near structures, and visitors and employees at recreation areas** from falling of hazardous trees killed or damaged by fire. These locations have large numbers of dead and fire damaged trees (>75% basal area (BA) mortality). There is “Very High” risk (likely, major) in areas having 1-75% BA mortality, as well. Although there are generally lower numbers of dead and fire damaged trees, the threat will result in major consequences to human life and safety (and property). An estimated 340 road miles have moderate to high levels of basal area mortality, where fire-killed or damaged trees are within falling distance to reach a road on state and private lands. There are over 263 acres of hazard trees within the 100' buffer surrounding all structures. There are 180 structures in areas that suffered 50% or greater basal area mortality. Another 76 structures are in areas that suffered less than 50% basal area mortality. Specific areas of concern noted by the ETART include all the Rock Creek Fish Hatchery and the Rock-ed Outdoor Education Center.

Recommendation: Temporary road and sites closures until hazard trees are mitigated, minimize exposure to buildings, fell danger trees within striking distance of roadways and structures. Post hazard warning signs. Inform county emergency management, stakeholders and private landowners. Complete site-specific assessments for specific treatment recommendations.

**Available resources for on-the-ground assessment of danger/hazard trees**

- OSU Fire Extension has recorded several post-fire webinars. Link to webinars and an extensive summary of available resources: https://extension.oregonstate.edu/fire-program.
- ODF post-fire resources, including information on locating stewardship foresters: (https://www.oregon.gov/odf/fire/Pages/afterafire.aspx).
- Field Guide for Danger Tree Identification and Response along Forest Roads and Work Sites in Oregon and Washington:
- http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fseprd512960.pdf).
- Post-fire tree mortality assessment and marking guidelines: https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fseprd814664.pdf).

To arrange for on-the-ground training contact ODF or OSU Extension Services. USFS State and Private Forestry also has experts on staff to help with post-fire trainings at the request of ODF.

### 2.1.2. DEBRIS FLOW, ROCK FALL, AND LANDSLIDES

Very High risk to **life and safety Rock Creek Fish Hatchery and at Rock-ed Outdoor Education Center** from debris flows and landslides. Facilities and structures located on values located in floodplains, debris flow paths or depositional zones. Steep slopes directly adjacent to hatchery; and outdoor education center property and the hatchery is located on toe of active landslide and within in deposition zone of debris flows.

Recommendation: Further evaluation is needed to define site-specific threats to values and identify appropriate mitigations. Information sharing with County Emergency Management, communities, and property owners on needs for further evaluation or assessment. Facility closures, education, install hazard warning signs, use weather alert systems or monitoring.

High risk to **life and safety at Annabell Road and Kelly Creek (private homes), Evergreen Lane and Dogwood Hotel, Hogback Creek, Honey Creek, Moore Hill Lane, OR138, Rock Creek Road, Susan Creek Campground, and Idywild Park** from debris flows, rock fall or landslides. Properties and communities are located in floodplains, at the mouth of channels, and within debris flow deposition zones.

Recommendation: Further evaluation is needed to define site-specific threats to values and identify appropriate mitigations. Information sharing with County Emergency Management, communities, and property owners on needs for further evaluation or assessment. Facility closures, education, install hazard warning signs, use weather alert systems or monitoring.

Low risk to **life and safety at Richard Baker Memorial Park, Smith Springs County Park, the Narrows Day Use Area, and Nonpareil Road** from debris flows, rock fall or landslides.

Recommendation: Further evaluation is needed to define site-specific threats to values and identify appropriate mitigations.

### 2.1.3. POST-FIRE FLOODING, FLOATING DEBRIS, AND OTHERS

Intermediate risk to **visitors and employees at Rock Creek Fish Hatchery and at Rock-ed Outdoor Education Center** from logs, debris and sediment flow into fish hatchery. High mortality of trees upstream, steeps slopes with debris flow hazard.

Recommendations: Close facilities, clean debris and logs as needed and consider berms/debris diversion structures. Inform county Emergency Management, use hazard warning signs and early warning system/weather alerts.

## 2.2. Property Summary

Very High risk to **property at Rock Creek Fish Hatchery and at Rock-ed Outdoor Education Center** from debris flows and landslides, as well as logs, debris and sediment flow into hatchery. Facilities and structures located on values located in floodplains, debris flow paths or depositional zones. Steep slopes directly adjacent to hatchery; and outdoor education center property and the hatchery is located on toe of active landslide and within in deposition zone of debris flows. There is a high mortality of trees mortality upstream, steep slopes with debris flow hazard increases potential for damage, but unlikely to be total loss. A potential threat is clogging of water intakes from increased loading of sediment and large wood (e.g., Rock Creek Fish Hatchery).

Recommendation: For protection of water intakes, increase frequency of inspection and debris removal, and outreach to the private landowners with water intake systems to increase awareness of the potential threats and recommended mitigations. Clean debris and logs as needed; consider berms/debris diversion structures.

Further evaluation is needed to define site-specific threats to values and identify appropriate mitigations for geologic hazards. Information sharing with County Emergency Management, communities, and property owners on needs for further evaluation or assessment. Facility closures, education, install hazard warning signs, use weather alert systems or monitoring.

High risk to **properties at Annabell Road and Kelly Creek, Evergreen Lane and Dogwood Hotel, Hogback Creek, Honey Creek, Moore Hill Lane, OR138, Rock Creek Road, Susan Creek Campground, and Idywild Park** from debris flows, rock fall or landslides. Properties and communities are located in floodplains, at the mouth of channels, and within debris flow deposition zones.

Recommendation: Further evaluation is needed to define site-specific threats to values and identify appropriate mitigations. Information sharing with County Emergency Management, communities, and property owners on needs for further evaluation or assessment. Facility closures, education, install hazard warning signs, use weather alert systems or monitoring.

### Resources for private landowners

The Natural Resources Conservation Service (NRCS) provides information about actions that can be take on your private property. Please see this list of fact sheets (click here) for details different treatment options that can be taken to combat erosion risks.

High risk to **private home and access road at mouth of Honey Creek** from debris and hillslope slump blocking and redirecting flow into floodplain. Narrow channel with adjacent steep slopes and no understory increases potential for channel diversion and overbank flows, depositing sediment on property and impacting water quality.

Recommendation: Property acquisition. Inform stakeholders of risks and advise on threat mitigation recommendations (e.g. engineering teams to inspect culverts and other road infrastructure) and storm alert systems. For hillslope stabilization there are multiple proven treatments effective against low degrees of hillslope erosion: mulching, slash spreading, erosion barriers, wattles, silt fences, debris deflectors, and protective fences.

High risk to **privately-owned land near Honey Creek** from hillslope erosion and sediment bulked flows depositing sediment onto private property/burned homesite. Property is located at the bottom of a confined drainage within the floodplain. There are no structures on the property, but deposited sediment may impede access and use of the site.

Recommendation: Further evaluation is needed to define site-specific threats to values and identify appropriate mitigations. Inform stakeholders of risks and advise on threat mitigation recommendations (e.g. engineering teams to inspect culverts and other road infrastructure) and storm alert systems. For hillslope stabilization there are multiple proven treatments effective against low degrees of hillslope erosion: mulching, slash spreading, erosion barriers, wattles, silt fences, debris deflectors, and protective fences.

High risk to **private residences along Evergreen Loop Road and Evergreen Road** from debris, sediment and clogged culverts. Hazard trees with debris in road ditches and culvert inlet basins increasing threat for water diversion to plug culverts and damage road surface.

Recommendations: Hazard tree removal and road maintenance. Inform stakeholders of risks and advise on threat mitigation recommendations (e.g. engineering teams to inspect culverts and other road infrastructure) and storm alert systems. For hillslope stabilization there are multiple proven treatments effective against low degrees of hillslope erosion: mulching, slash spreading, erosion barriers, wattles, silt fences, debris deflectors, and protective fences.

High risk to **Winchester Dam** from woody debris and sediment deposition. Structure is designed to have flow overtop the dam. Steep slopes having high mortality of trees upstream increase potential for mobilized debris; debris will stack up against the dam but should flow over during high water.

Recommendations: Update the Emergency Action Plan to account for woody debris. Remove any logs that threaten the water intake structure or the fish ladder at the ends of the dam.

Intermediate risk to **Quarry on BLM Road 25-2-11 (private property/infrastructure)** because of high probability for debris flow.

Recommendation: Further evaluation is needed to define site-specific threats to values and identify appropriate mitigations.

Low risk to **property at Richard Baker Memorial Park, Smith Springs County Park, the Narrows Day Use Area, Nonpareil Road, and power transmission lines (south side of the fire and along OR193)** from debris flows, rock fall or landslides.

Recommendation: Further evaluation is needed to define site-specific threats to values and identify appropriate mitigations.

Low risk was found for **Douglas County and private roads** from debris flow and plugging potential causing culvert failure. The roads at risk within the Archie Creek Fire burned areas are located primarily within or below areas of high and moderate SBS. There is a future threat to travelers along the roads within the burned area due to the increased potential for culverts plugging with sediment or debris which could washout sections of the roads. With the loss of vegetation, normal storm frequencies and magnitudes can more easily initiate erosion on the slopes, and it is likely that this runoff will cover the roads or cause washouts at drainage facilities (culverts) or stream crossings. These events make for hazardous access to forest roads and put the safety of users at risk. These roads will require minimal action to maintain open and safe to all traffic. See Appendix A for Road Treatment Cost Estimates.

Recommendations: Storm proofing and Storm Inspection and Response

- Bar-L Ranch Road (County). Hillslope and road ditch debris diverting runoff and crossing failures from burned culverts increase potential for road damage. One culvert was burned in fire resulting in collapsed road surface (isolated occurrence). Replace burned culvert.
- Evergreen Loop Road (County) for road surface damage. Hillslope and road ditch debris diverting runoff and debris in culvert basin increase potential for road damage. Evidence of pre-existing culvert plugging which will likely be exacerbated by increased runoff from burned drainages (isolated occurrences).

Recommendations: Coordination with landowner on storm patrol and hillslope stabilization

- Beaty Creek crossing at Road 24-3-33.7 (Federal/Private Industrial). Debris and sediment in culvert basin plugging culvert and impacting surrounding road fill. Small drainage area with gravelly soils and low SBS above crossing. Road primarily accesses private and BLM timberlands.
- Hinkle Creek crossing at Road 24-3-31.1 (Federal/Private Industrial). Debris and sediment in culvert basin plugging culvert and impacting surrounding road fill. Small drainage area with gravelly soils and low SBS above crossing. Road primarily accesses private and BLM timberlands.
- Rock Creek Bridge (Federal/Private Industrial). Large log was anchored under bridge footing, which burned up, resulting in a gap and possible erosion under bridge footing under elevated flows. The stream is large with a wide floodplain, but increased debris and sediment may rise water levels to area of gap in bridge footing. Destabilized bridge footing would require costly repairs; road is a main access route through Rock Creek.
- Harrington Creek Bridge (Federal/Private Industrial). Debris and sediment deposition upstream of bridge possibly damaging bridge footings. Very narrow channel and crossing with moderate SBS and abundant hillslope and channel debris above bridge. Mobilized debris may damage bridge resulting in loss of use; bridge provides access to private industrial and BLM lands.
- Kelly Creek Culvert (Federal/Private Industrial). Debris and sediment deposition upstream of culvert increases potential for damage to or loss of road crossing. Large diameter culvert has restricted in-flow and moderate SBS above stream channel with large amount of standing dead wood. Armored culvert inlet basin, deep fill and paved road would result in substantial cost to repair damage.

Low risk to **private residences along Bar L Ranch Road and Lone Rock Road** from debris, sediment and burned culvert. Potential for hillslope and road ditch debris to divert runoff and cause failure of burned culvert, increasing threat for water diversion to damage road surface. Risk for property damage from falling trees.

Recommendations: Hazard tree removal and replace culvert on Bar L Ranch Road.

Low risk to **private homes along N. Umpqua River on Smith Springs Drive** from increased bank erosion. Existing eddy known to collect debris and logs; expected increase in mobilized debris with potential for bank erosion and nuisance flooding.

Recommendations: Education and outreach with property owners.

### Road Treatments

- Storm Proofing. Clean/pull ditches, clean stream crossing culvert inlets/outlets and relief culverts, run out ditches and catchment basins of sediment, debris and rock. Out slope the road prism where appropriate. Replace or repair damaged culverts pending the need of primary maintainers. Slotted riser pipes or culvert end sections could be installed where feasible and appropriate to reduce the potential for sediment and debris plugging of existing culverts.
- Storm Inspection and Response. Follow-up to storm proofing to monitor functionality post-storm event. Monitor road conditions after a storm for the first year, deploying personnel to inspect and react as appropriate. Re-storm proof may be needed after a damaging storm to keep ditches, culverts and critical dips in working order.
- Storm Patrols. Monitor road drainage structures and debris flow treatment structures after significant storm events to ensure the maximum drainage capacity is maintained until the natural revegetation of the burned area has occurred. Maintain and/or repair any damage to road surfaces. Remove sediment and debris from drainage and treatment structures and stabilize head cutting in streams and drainages to prevent further degradation of channels. Monitor the movement of large woody debris, make a determination to remove material before it contacts bridge piers, abutments or culverts.
- If feasible and cost effective, replace culverts to handle the post fire flows. Culverts being replaced should be sized on predicted increase in flows and installed with minimum fill cover and heavy armoring. If culvert is not replaced, proceed with monitoring and ditch cleaning along the roads identified in the Archie Creek Fire Engineering Report.

## 2.3. Natural Resources Summary

### 2.3.1. SOIL AND WATER

High risk to **soil productivity** from accelerated erosion. High and moderate SBS on steep slopes increase potential for loss of topsoil. Ground cover in clear-cut areas may take longer than 2-5 years to establish and decrease longer term erosion.

Recommendations: Further evaluation is needed to define site-specific threats to values and identify appropriate mitigations. Apply mulch, preferably by chipping existing dead vegetation. Re-establish vegetation cover.

### 2.3.2. FISH AND WILDLIFE HABITAT

Very High risk to **T&E fisheries habitat** from water quality impairments (temperature). Loss of riparian shading leading to increased stream temperatures. A number of stream reaches experienced complete or partial loss of trees in riparian areas. This will result in increased solar radiation entering streams until vegetation regenerates. Temperature increases are likely to last multiple years (potentially 10+ years in high burn severity areas) thereby impacting several generations. In a number of locations, stream temperatures during summer were already close to the thermal tolerance limits for fish species. The actual magnitude will depend on future climatic conditions and pace of regeneration.

Recommendations: Work with partners to encourage natural regeneration and/or reforestation with mixed hardwood conifer.

High risk to water quality that supports **T&E habitat in Rock Creek basin** from contaminants from burned debris. Runoff from developed lands containing hazardous wastes poses risk to aquatic species. A number of urban areas were subject to fire damage and are in proximity to waterways. Efforts to remove hazardous wastes are underway but in some instances surface runoff from rains has already occurred or will occur before wastes are removed. Environmentally persistent contaminants introduced to waterways may have multigenerational impacts. Other more transient chemicals will likely impact one to two generations within the area of exposure.

Recommendations: Work with partners to identify and prioritize hazardous waste removal in proximity to waterways.

High risk for decreased **productivity at Rock Creek Hatchery** from debris and/or sediment impinging on water intake screens during high flows. A large amount of the Rock Creek watershed experienced high SBS and vegetation mortality. There is increased potential for delivery of sediment, ash and debris to the river this winter. High volumes of sediment and debris that damage intake systems or impact water quality are likely to have considerable impact on future ability to rear fish on site.

Recommendations: Implement increased monitoring and frequent screen regiment.

Low risk to **T&E fisheries habitat** from water quality impairments (turbidity). Runoff of ash and sediment represents a near-term threat to spawning success for salmonids and lamprey. A large portion of several watersheds containing spawning habitat for salmon, trout and lamprey was burned leaving significant ash deposits. Control measures will not be sufficient to prevent this from entering waterways during rain events. Some areas may experience increased redd failure, but likely there is sufficient alternate spawning habitat to sustain populations.

No treatment recommended.

Low risk to **T&E fisheries spawning, rearing and refugia habitat** access for ESA-listed species. Increased runoff resulting from lack of vegetative cover may result in higher peak flows leading to increased scour of redds and/or displacement of some species. A number of watersheds experienced high levels of vegetative mortality at mid- to low elevations. Winter forecasts suggest a likelihood of wetter weather. This combination of conditions creates higher likelihood of significant rainstorm/runoff events with impacts are likely to be transient (affect 1-2 generations) and spatially heterogenous.

No treatment recommended.

Low risk for impacts to **migration habitats or loss access to rearing and spawning habitats** from damage to Rock Creek Fish Ladder. Rock Creek watershed experienced a large percentage of high SBS and vegetation mortality. There is increased potential for debris to be mobilized and delivered to the river this winter (and in subsequent winters). Debris blocking or damaging the fish ladder will impact the ability of fish to move upstream

Recommendations: Implement increased monitoring and frequent ladder cleaning regiment to remove debris blocking fish passage.

Low risk to **T&E fisheries spawning, rearing and refugia habitat access** for ESA-listed species. Increased runoff resulting from lack of vegetative cover may result in higher peak flows leading to increased scour of redds and/or displacement of some species. A number of watersheds experienced high levels of vegetative mortality at mid- to low elevations. Winter forecasts suggest a likelihood of wetter weather. This combination of conditions creates higher likelihood of significant rainstorm/runoff events with impacts are likely to be transient (affect 1-2 generations) and spatially heterogenous.

No treatment recommended.

### General Fish and Wildlife Recommendations

**Early Seral Habitat - Seneca Jones Timberlands.** Assist landowners with reseeding to benefit deer and elk, provide soil stability and minimize expansion of invasive plants in areas of moderate to high SBS. Timberlands experienced high vegetation mortality (76-100% BA) over a large area. Reseeding and stabilizing roadbeds is known to have major benefits to maintain early successional species as well as reduce erosion and decrease susceptibility for invasive plants to occupy disturbed areas.

**Maintain or Restore Aquatic Habitat Connectivity.** Work with partners to identify priorities and options for fish passage at stream crossings; implement aquatic organism passage options when upsizing or replacing burned/washed out culverts. Given scale of fires and the number of culverts on the landscape, it is likely some culverts were or will be impacted. Restoring passage allows fish to access suitable habitat or refugia if primary habitats are impacted by post-fire events.

**Riparian Shade - Rock Creek Basin, lower reaches of Honey Creek, Susan Creek, Cougar Creek, Williams Creek, Wright Creek and Fall Creek.** Work with partners to identify artificial revegetation and/or natural regeneration practices that rapidly restore riparian shading. Locations are variable depending on burn severity and extent of active management. Many streams within the burn areas have summer temperatures close to thermal tolerance limits. Allowing a mix of hardwood/conifer in riparian areas promotes more rapid recovery of intermediate shading from hardwoods may be key to ensuring these streams remain suitable during summer in the near term.

**Large Woody Debris (LWD) - Rock Creek Basin, Hinkle Creek Basin, lower reaches of Canton Creek, South Fork Calapooya Creek and Engels Creek.** Work with partners to encourage alternative salvage harvest practices that retain LWD, to the extent practicable, for recruitment into stream channels. Locations are variable depending on extent of post-fire salvage harvest occurring within riparian zones. Many of the rivers and streams have historically low levels of LWD. Maintain standing or dead trees within riparian areas could potentially reset the system and provide substantial long-term benefits in terms of creating suitable habitat for aquatic and terrestrial species. As these trees enter streams and rivers, they create high quality habitat for salmonids.

**Keystone species.** Work with partners to identify alternative artificial revegetation and/or natural regeneration practices for long-term beaver habitat. Locations are variable depending on management goals. Promoting hardwood regeneration in riparian areas provides conditions for beaver to construct dams that benefit a range of aquatic species. Beaver are ecosystem engineers that create habitats for many aquatic species, including salmonids. To build dams, beavers require suitable plant materials (typically willow, alder, etc.).

**Refugia (Intact Ecosites/Ecosystems).** Work with partners to encourage natural regeneration and minimize disturbance to the extent practicable to protect intact landscapes with low burn severity, low vegetation mortality and low road/trail disturbance. These areas are important refugia and source areas for species displaced by the fire, particularly late seral obligates. Given large areas of habitat burned at moderate to high SBS, maintaining high quality core habitat is critical to retaining source populations of some species, as loss of late successional forest will have long-term effect on species such as the Northern spotted owl.

**Standing Dead Wood.** Work with partners and landowners to encourage natural regeneration and limit salvage harvest, to the extent practicable, to retain burned wood on the landscape. Large areas with moderate to high SBS and high vegetation mortality result in a high density of snags and woody debris that are used by a variety of terrestrial species. Use of severely burned forest by late successional species such as Northern spotted owl will depend on patch size and availability of unburned or lightly burned habitat nearby.

**Early-successional Ecosystems.** Work with partners to prioritize revegetation and reseeding for native plant species to promote habitats for pollinators, high-value forage and minimize expansion of invasive plant species. Appropriate post-fire management of forest and meadow early seral habitats ensures desirable successional pathways that are critical to recovery of early seral plant species, particularly in moderate to high SBS areas. The fire converted large areas of forest to early seral habitat that are vulnerable to invasive species, unregulated vehicle intrusions and other disturbances. Response actions are needed to regulate disturbances and control expansion of invasive plant species.

**Security Cover.** Work with partners to maintain existing road closures and identify needs for additional closures that limit motorized disturbances to protect or provide security cover. Previously closed roads may now be accessible to motorized vehicles, exposing areas with reduced hiding cover and sensitive unburned areas. Limiting motorized vehicle access to these areas will protect vulnerable species and preserve secure habitats. Additional road closures may be needed, particularly if deer and elk populations increase.

**Slope Stabilization and Erosion Control.** Work with partners to implement treatments to stabilize hillslopes, reseed and plant where appropriate. Reseeding, planting or mulching areas with high SBS and high vegetation mortality can improve terrestrial and aquatic habitats by reducing soil erosion and decreasing debris flow risk.

### 2.3.3. NATIVE PLANT COMMUNITIES SUMMARY[1]

Very High risk to **oak savannah and woodlands in the French Creek area** from the spread invasive plants and/or expansion of established local weed populations. There is increased potential for loss of habitat leading to decline in native plants in areas with high SBS. Significant populations of Oregon Department of Agriculture (ODA) class A and B weeds are documented within or near the burned area. Expansion of noxious weeds could impact both grazing productivity and habitat value.

Recommendations: Early Detection Rapid Response (EDRR) to survey and control priority weed species within the burned area. Monitor low SBS areas west of drainage (beyond fire line). Explore bio-control options for common tansy via ODA.

Very High risk to **native plant communities bordering Rock Creek Road (78)** from spread of invasive plant species. Fire effects, fire suppression operations, road repair and maintenance, and salvage harvest activities increase the threat for expansion of existing invasive plant populations. Road shoulders and pullouts do not themselves represent significant botanical or habitat resources but are disturbance areas having increased noxious weed populations that threaten all other areas considering the susceptibility of the burned area and increased traffic along the road corridor. High volume of salvage harvest traffic on the Rock Creek road is expected to spread existing populations of weeds to new areas, including mapped populations of slender false brome.

Recommendations: Early Detection, Rapid Response (EDRR) to survey and control priority weed species. Install weed wash station at intersection with Highway 138.

High risk to **native riparian forest communities along Rock Creek and tributaries** from the spread of invasive plants into habitats with high SBS. Dominant hardwoods in riparian areas are more resilient to fire than upland species, based on species response and burn severity, but communities will face threats of increased sediment and noxious weed introduction from nearby roads. Disturbance from fire, fire suppression operations, road repair/maintenance and post-fire salvage activities increase the potential for expansion of invasive species, increasing competition for native plant recovery and loss of native plant habitat.

Recommendations: Early Detection Rapid Response (EDRR) to survey and control priority weed species (slender false brome, Armenian blackberry, Scotch broom). Consider targeted tree planting. Monitor native vegetation recovery to determine need and efficacy of replanting.

1 See appendix B for Invasive Plant Treatment Design and Cost Estimates

High risk to **dry meadows/rock balds/talus slopes (middle elevations)** from expansion of invasive plants into sensitive habitats. Dry meadows and rock balds are relatively rare habitat types with low commercial or recreational use. Rare and endemic plant populations are present in some locations. They are also often difficult to access making weed control and survey harder than in other areas. Disturbance from fire and fire suppression operations resulting in bare soil increase potential for impacts to rare plants and loss of habitats.

Recommendations: Early Detection Rapid Response (EDRR) to survey and control priority weed species. Monitor mortality and recovery of native species in select sample locations.

High risk to **wet meadows/palustrine wetlands** from spread of invasive plants into sensitive habitats. Fire effects in wetlands west of the cascades are not well documented, but significant changes to the plant community may occur given canopy reduction and exposed soil. Disturbance from fire resulting in bare soil and loss of canopy raises concerns for impacts to forested wetland habitats.

Recommendations: Early Detection Rapid Response (EDRR) to survey and control priority weed species, especially in locations near roadways (common teasel, reed canarygrass, Armenian blackberrry). Possible targeted restoration plantings.

Intermediate risk to **Hinkle Creek drainage riparian areas** from expansion of invasive plants into native habitats. Dominant hardwoods in riparian areas are more resilient to fire than upland species, based on species response and burn severity, but communities will face the threat of sedimentation and noxious weed introduction from nearby roads. Disturbance from fire, fire suppression operations, road repair/maintenance and post-fire salvage activities increase the potential for expansion of invasive species, increasing competition for native plant recovery and loss of native plant habitat. Burn severity and vegetation loss is lower than within the Rock Creek drainage, reducing the potential severity of weed establishment and spread.

Recommendations: Early Detection Rapid Response (EDRR) to survey and control priority weed species along road corridor (slender false brome, Armenian blackberry, Scotch broom). Possible targeted tree planting.

Low risk to **North Umpqua River riparian areas (Rock Creek Road to Umpqua NF boundary)** from spread of invasive plants in riparian habitat along the highway corridor. Burn severity is lower here than in other areas, however significant weed pressure from the highway existed pre-fire.

> Recommendations: Early Detection Rapid Response (EDRR) to survey and control priority weed species, particularly slender false brome.

Low risk to **forestlands used for timber resources** from spread of invasive plants into tree plantations along roads and during salvage logging activities. Disturbance from fire and suppression operations resulting in bare soil increases susceptibility for further decreases in productivity from weed populations that may spread into valuable habitat areas. Presence of noxious weed species can inhibit tree growth.

> Recommendations: Install weed wash station where fire perimeter intersects Highway 138.

## 2.4. Cultural Resources Summary

Cultural resources are non-renewable and can be adversely affected by post-fire erosion and related events, such as debris flows, tree falls, exposure of sites and artifacts to looting and displacement. In addition, proposed ETART treatments can also affect cultural resources and if federal funds are involved then S.106 consultation with Tribes and the Oregon SHPO must also be addressed. Under the ETART process, attempts were made to engage state and local cultural resource specialists to assist in determining critical values, risks and treatments, however no individuals were available to perform this work due to staffing and project workload factors in several state and federal agencies. In addition, the acquisition of GIS (feature data classes) from the Oregon SHPO for state and private lands in the fire area was not timely and thus fine-grained analysis of site locations as compared to moderate to high burn severity in the fire area could not be performed.

Given the lack of cultural resource personnel and completion of a critical values analysis, we recommend that FEMA, State and local agencies seek to acquire GIS data on archaeological and historic sites directly with Oregon SHPO and then apply the ETART process to determine the cultural resource critical values, perceived risks and propose treatments where the likelihood of success is greatest. What follows are some general guidelines for addressing values, risks and treatments.

Cultural resources reflect varying social, cultural, and scientific values to society at large and to specific cultural groups, such as area tribes. Cultural resources can be categorized into four broad types: pre-contact archaeological sites, historic archaeological sites, historic structures and traditional cultural properties/sacred sites. The fire area contains cultural resources spanning at least the last 10,000 years of time. These features include task-specific activity areas and camps such as sites of spiritual and cultural value to tribes, pre-contact lithic scatters, fishing stations, rock shelters, vision quest sites, historic trails, wagon roads and highways, historic mining and logging features and artifacts, historic structures, recreation and administrative sites.

In order to determine which cultural resources should be considered as “critical values” under ETART, a triage process is used to identify critical heritage values based on their listing or eligibility to the National Register of Historic Place, and scientific or cultural values. Not all cultural resource sites should be considered under the ETART process. Ideally a small group of specialists, including representatives of interested tribes should prioritize the site inventory to reflect (in order of value) sites listed on the National Register of Historic Places (NHRP), sites determined as eligible to the (NRHP), and sites identified as having traditional cultural or spiritual values to tribes or other ethnic groups. Cultural resource sites that are designated as unevaluated are not automatically considered under ETART, unless their value is exceptional and would likely be easily determined eligible or listed on the NRHP.

Once the above critical values determination is made, a GIS analysis is used to identify their proximity to Moderate or High soil burn severity areas. The BAER risk matrix (Figure 6) is used to determine if stabilization treatments or other protection actions are warranted. Treatments range from point protection to prevent damage from erosion and/or debris flows, mulching or slash dispersal to cover exposed sites having a high likelihood of looting, directional felling of danger trees to prevent damage to archeological deposits or historic structures and treatment effectiveness monitoring. In addition, S.106 compliance is required for other recommended and federally funded ETART treatments that may affect cultural resources.

# 3. Monitoring and Management Recommendations

Inform stakeholders of risks and advise on threat mitigation recommendations (e.g. engineering teams to inspect culverts and other road infrastructure) and storm alert systems. For hillslope stabilization there are multiple proven treatments effective against low degrees of hillslope erosion: mulching, slash spreading, erosion barriers, wattles, silt fences, debris deflectors, and protective fences.

## 3.1. Watershed Response and Hydrologic Analysis - Monitoring Recommendations

Modeling suggests that some watersheds affected by the Archie Creek Fire will experience increased peak flows due to the extent and intensity of the fire. With this in mind, the team recommends installation of one or more near real-time (NRT) precipitation gages in or near the burn area. An NRT precipitation gage provides invaluable information about the localized intensity and amount of precipitation as it happens. Based on these data, the National Weather Service (NWS) can issue alerts to emergency managers, road crews, and other partners to warn of increased potential for flooding and debris flows that could threaten lives or damage homes, roads, and other infrastructure.

In addition to improving emergency response, expansion of the precipitation monitoring network would lead to a better understanding of how the amount and timing of runoff change due to fire in mountainous parts of the Pacific Northwest. At present, little information is available in this regard because large, intense fires have been relatively rare in this region.

Gaging stations are present in watersheds within and adjacent to the burned areas of the Archie Creek Fire with periods of record existing prior to fire outbreak. Such circumstances create opportunities for performing paired-watershed analyses to understand impacts of wildfires on hydrologic response. The paired-watershed method can be used to develop a runoff relationship between an experimental (i.e. burned) and control (i.e. unburned) watershed. Catchments can be instrumented to collect rainfall and runoff data to assess changes in flood flow frequency, magnitude, timing, and hydrograph shape. Further developing these relations can assist with future evaluations of post-fire flood magnitude and hydrologic response in ungaged watersheds (Moody and Martin, 2001).

## 3.2. Geologic Hazards - Management Recommendations

The finding in this report are from a rapid assessment of areas prone to geologic hazards. Most properties identified in this report were not fully assessed. A more complete assessment requires examining the on-the-ground characteristics of each property at risk. In some cases, this report points to high hazard areas that could benefit from “further evaluation”, therefore, additional site-specific assessments are recommended. The results of a site-specific evaluation should address protecting homes from the impacts of large debris flows, which may necessitate additional design resources and consultation with engineers that is outside the scope of this evaluation. Engineered debris flow diverting structures were not evaluated by this report. These structures need to be surveyed and designed for specific areas they would be needed.

## 3.3. Road Management Recommendations

### 3.3.1. STORM INSPECTION AND RESPONSE

Storm inspection and response should be completed after high rainfall events on all roads open to the public. Subsequent patrols should be coordinated with all the agencies and private ownerships providing public access roads within the fire perimeter, including USFS, the BLM, Douglas County, and ODOT. Continue storm inspection and response until vegetation has reestablished in affected watersheds for at least two years.

### 3.3.2. ROCK FALL, CHANNEL DEBRIS AND FLOOD MITIGATION ACTIONS

For locations where rock fall may occur, install hazard warning signs and increase frequency to clear and maintain primary travel routes. During storm inspection and response, remove debris from channels upstream of road crossings that may be mobilized by flooding. Roads that become blocked from debris or damaged from road crossing failures could result in loss of access by emergency responders and residents being stranded. Inform county emergency managers of the high-risk locations and post signs to educate residents and the public.

## 3.4. Fish/Aquatic Habitat - Management Recommendations and Monitoring

With respect to hazard tree mitigations, the primary objective is to ensure exclusion of employees and the public from these sites and to remove the hazard trees. Treatment of large wood is somewhat more complex because it is a beneficial, natural feature in streams. Add to this that many river reaches are difficult for heavy equipment (capable of removing the wood) to access. Thus, the treatment for wood in streams is a combination of good signage and education to warn boaters of the risks posed by large wood.

Near-term success in engaging partners can be monitored by number of projects on which engagement occurs. Over the mid- to longer-terms, success can be measured by habitat variables and populations metrics, such as LWD recruitment into stream channels and escapement of salmonids or population counts of terrestrial wildlife. In addition, partners should prioritize monitoring to increase understanding of species response to fire and post-fire habitat treatments. Likewise, habitats should be assessed over time to determine effectiveness of and responses to treatments, changes in species composition, and presence of invasive species.

# Resource Reports

## 1. Weeds Specialist Report

Simon Apostol, Cascade Environmental Group

### 1.1. Summary

#### 1.1.1. OBJECTIVES

- Evaluate fire impacts on vegetation and plant communities.
- Provide management recommendations to promote recovery and protection of vegetation resources.
- Assess potential impacts on threatened, endangered, and rare plants.
- Assess potential impacts to critical or priority habitats.
- Identify noxious weed populations and threats.
- Recommend invasive control, assessment, restoration, and monitoring activities to be undertaken by public and private partners.

#### 1.1.2. CRITICAL VALUES

Threats identified within and adjacent to the burned area include the following:

- Expansion and establishment of invasive species in critical habitats due to direct effects of fire, suppression activities, and post-fire salvage logging. Identified at-risk habitats:
    - Riparian Areas along major perennial streams, including the Hinkle Creek and Rock Creek watersheds
    - Wet meadows and palustrine wetlands
    - Oak woodlands and savannahs
    - Rock balds, talus slopes, and dry meadows
- Expansion and establishment of invasive species in commercial timber production and grazing areas, which reduces economic productivity.
- Loss of rare and endemic plant populations due to direct impacts of the fire, suppression activities, and post-fire salvage logging.

### 1.2. Resource Condition and Setting

The Archie Creek Fire was detected on September 8, 2020 at approximately 7:30 a.m. in the Steamboat Springs area along Highway 138, east of Glide, OR. On September 10th, it merged with the Star Mountain Fire in the Susan Creek area. The fire quickly encompassed 131,580 acres.

The fire burned areas managed by the Umpqua National Forest, North Umpqua Ranger District, and the Roseburg District of Bureau of Land Management. Private land affected by the fire included commercial timberlands and the communities of Rock Creek and Steamboat along both sides of the Umpqua River. The Rogue-Umpqua Scenic Highway was also impacted.

**Table 1. Archie Creek Fire land ownership**

| Ownership | Acres | % of total |
|---|---|---|
| Bureau of Land Management | 40,429 | 31% |
| Private | 63,847 | 49% |
| State | 39 | Less than 0.01% |
| Forest Service | 26,645 | 20% |
| Undetermined | 620 | 0.47% |
| **Total** | **131,580** | |

The majority of non-federal burned lands are comprised of commercial timberlands, with variously aged stands. Commercial forests prre-burn were primarily dominated by Douglas-fir, but with lesser components of incense cedar, western hemlock (*Tsuga heterophylla*), red alder (*Alnus rubra*), and bigleaf maple (*Acer macrophyllum*). Riparian corridors within these areas are primarily hardwood-dominated. Riparian tree cover of most streams consists largely of alder and bigleaf maple, with various willow species growing along and within streams, while the Umpqua river corridor and some watersheds to the south of the river also include a large number of conifers. The uplands throughout the fire were subject to severe burns, with nearly 100% vegetation mortality. In riparian corridors, fire intensity ranged from moderate to severe. Bigleaf maple and willows show some initial signs of recovery via root sprouting, but it is expected that there will be significant canopy loss, although the extent of mortality may not be apparent until spring 2021.

The western extent of the fire, both north and south of the river corridor, reached lower and middle-elevation slopes comprised of a patchwork of oak woodlands, meadows used for commercial livestock (cattle and sheep). The fire impacts also include rural residential areas, especially to the south of the Umpqua River near the City of Glide. In this area, oak woodlands are dominated by Oregon White Oak *(Quercus garryana*) with an understory of poison oak (*Toxicodendron diversilobum*), oceanspray (*Holodiscus discolor*), and other drought-tolerant shrubs. Several species of conifers have encroached into these areas as well, including Douglas-fir (*Pseudotsuga menziesii*) and incense cedar (*Calocedrus decurrens*). Burn severity within oak-dominated systems was highly variable, ranging from near 100% mortality to low-intensity understory burns limited to the herbaceous layer. Several low-intensity spot fires jumped the fire line and burned in these habitat types, resulting in a burn intensity patchwork.

A mix of native and nonnative pasture grasses, including California oatgrass (*Danthonia californica*), perennial ryegrass (*Lolium perenne*), and orchard-grass (*Dactylis glomerata*) dominate meadows used for commercial grazing. These areas generally occur west of the burn perimeter, but the fire burned smaller patches within otherwise unaffected areas, as observed in the oak woodlands.

Scattered throughout uplands are dry meadows, rock balds, and steep rocky slopes dominated by Pacific madrone (*Arbutus menziesii*), Oregon white oak, various grasses. These dry meadows are also home to several rare and endemic species. Although relatively small in area, wet meadows and emergent wetlands occur throughout the burned area. Species composition varies depending on hydrology, ranging from common pasture grasses to heavily inundated wetlands dominated by common cattail (*Typha latifolia*), slough sedge (*Carex obnupta*), and smallfruit bulrush (*Scirpus microcarpus*). Occasional forested wetlands are also present within riparian corridors. Fire was patchy in these areas, and most herbaceous species will have been dormant during the fire, affording some level of protection depending on burn severity.

## 1.3. Assessment Methodology - Field Evaluations and Modeling

Literature reviews, GIS databases, and discussions with local and statewide experts from the Oregon Departments of Agriculture and Forestry in invasive control and forest management informed this assessment. Field reconnaissance consisted of on-site inspection of fire-impacted habitats on BLM lands and known weed infestation sites. The field reconnaissance was on November 11th, 2020.

Modeling Criteria used Natural Vegetation Protection Areas Buffer of 50 m, Invasive Species buffer of 50 m, and Vegetation Mortality >50% Basal Area loss. Inputs for the Natural Vegetation Protection Areas (Critical Values) included ODFW (Oregon Department of Fish and Wildlife) Conservation Opportunity Areas, ORBIC (Oregon Biodiversity Information Center) data for rare, threatened and endangered plants, and sensitive and unique habitats designated by the Oregon Conservation Strategy (prairie, grasslands, rock balds, wetlands, and oak woodlands). Invasive species data included information from iMap Invasives and WeedMapper.

## 1.4. Results of Field Work and Modeling

The analysis resulted in the identification of eight relatively distinct critical resources/values that may either be under threat directly or represent a threat to other critical values and resources if potential problems are left unaddressed. GIS Analysis helped to identify the areas of most significant vegetation mortality and soil burn severity (SBS) (Table 2).

**Table 2. Soil Burn Severity (SBS) and Acreage by land ownership**

| Private Land Burn Severity | Acres | State Land Burn Severity | Acres |
|---|---|---|---|
| Low | 7,911 | Low | 29 |
| Medium | 31,356 | Medium | 10 |
| High | 20,867 | High | 0 |

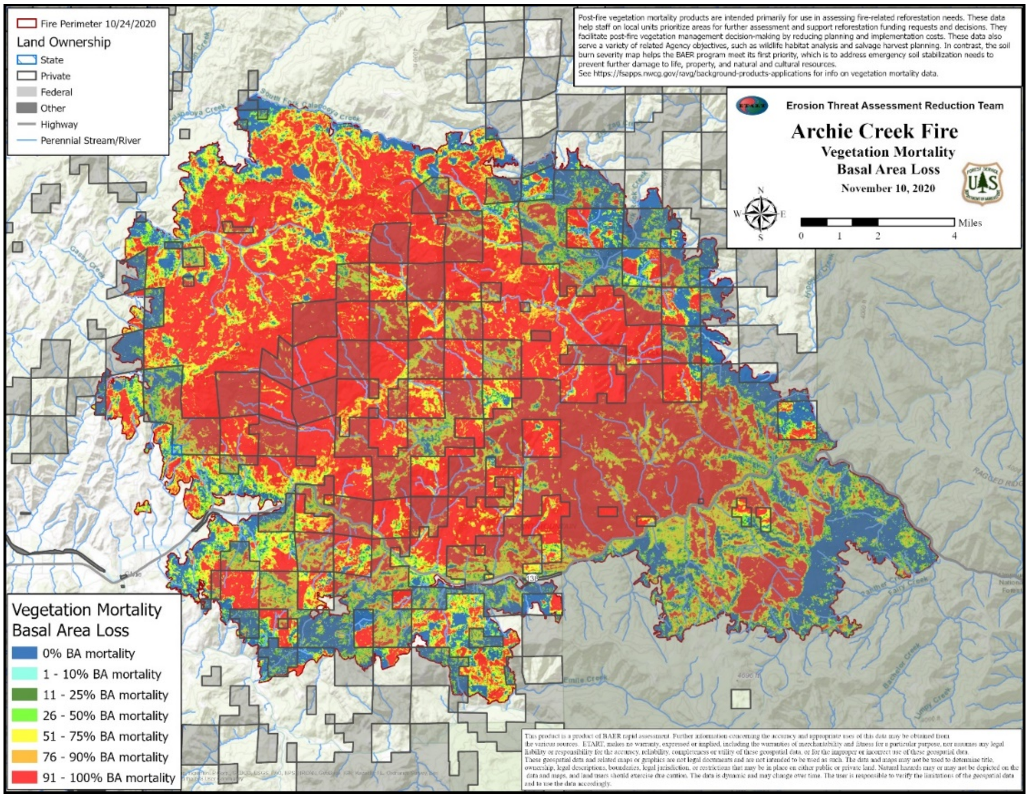


**Figure 1. Vegetation mortality with the Archie Creek Fire.**

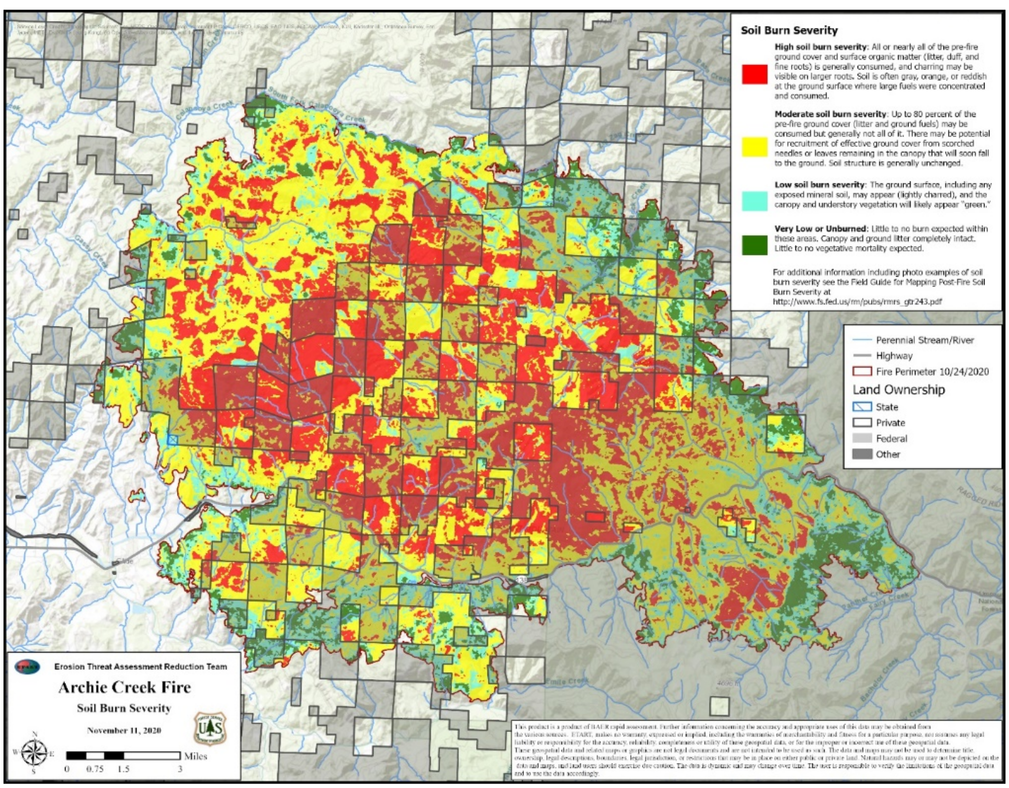


**Figure 2. Soil burn severity. Note high severity areas within the Rock Creek drainage in the north-central portion of the fire.**

### Oak Savannah and Woodlands – French Creek Area

Oregon White Oak (Quercus garryana) woodlands and savannahs represent the bulk of the lower elevation and west-facing slopes within the Archie Creek fire, ranging in composition from dense, mixed tree stands to open meadows with scattered trees. Fire historically has played a crucial role in the development and maintenance of oak woodlands and savannahs in Oregon, so the fire here may prove beneficial. However, decades of conifer encroachment and fuel buildup may have resulted in localized higher severity burns along the Archie Creek fire's western extent, resulting in mature oak loss and burning to mineral soil. These severe burn areas result in high mortality of seed banks and dormant perennial herbaceous species and open new ground for invasive species. Of particular concern are fast-growing annual grasses and common meadow invasives such as scotch broom and meadow knapweed. Additionally, a population of woolly distaff thistle (Carthamus lanatus) has been mapped within a spot fire west of the main burn. Adjacent meadows are used for commercial grazing, and livestock could act as a vector for transporting weeds into oak woodlands. Increasing populations of weeds may also reduce pasture productivity for grazing as well as degrading habitat value.

### Dry Meadows/Balds

Several types of dry meadows, rocky balds, hardwood stands, and talus slopes are present within the burned area and comprise nearly 4,000 acres. Many of these areas experienced somewhat lower severity burns than the almost uniform high-severity fire in conifer-dominated stands. As with the extensive oak savannahs and meadows, the largest threat to these systems is the expansion of invasive species into newly exposed soil. Meadow and oak habitats may contain rare and threatened plants, including Umpqua mariposa lily (Calochortus umpquaensis), a state endangered species and endemic in the Little River basin. Table 3 describes potentially sensitive species described within or near the burned area and their preferred habitat. Careful consideration of herbicide application and timing should be evaluated for any post-fire weed control in the areas that may support these species.

**Table 3. Locally Rare and Endemic Plants**

| Species | Common Name | Preferred habitat |
|---|---|---|
| Calochortus umpquaensis | Umpqua mariposa lily | Open meadows on serpentine soils within the Little River drainage. Shade tolerance is low. |
| Romanzoffia thompsonii | Thompson's mistmaiden | Vernally wet seeps on cliffs and rocky slopes. Low shade tolerance. |
| Pellaea andromedifolia | coffee fern | Dry, rocky slopes with high exposure. |
| Horkelia congesta | shaggy horkelia | Wet prairies. |

**Rock bald and powerline corridor along North Umpqua River and Highway 138.**

**Burned areas along Rock Creek, depicting little remaining understory and high mortality of riparian hardwoods.**

## Riparian Areas – Rock Creek, Hinkle Creek, and Umpqua River

Vegetation mortality in riparian habitats ranges from 26 to 90%, with Rock Creek and its tributaries the hardest hit among the significant watersheds. Riparian communities along Rock and Hinkle Creeks were dominated by young to mature hardwoods before the burn, with several willow species growing along banks and within gravel bars below the ordinary highwater mark. Plant survival in the Hinkle Creek watershed is notably higher than along Rock Creek. The Umpqua River riparian area is dominated mostly by conifers (Douglas fir, western hemlock, and incense cedar). Total mortality of hardwood trees may not be knowable until spring 2021, when significant canopy loss is expected. Extensive riparian tree mortality presents an opportunity for common weeds to invade riparian areas impeding the establishment of new trees, even for disturbance-adapted species like red alder. Weed sources are common in pullouts and along roadsides, including Armenian blackberry, Scotch broom, and common teasel. These species are fire resilient either via surviving root systems or from quick seedling establishment. Mapped populations of false-brome are present along segments of both Rock Creek Road and Highway 138. This species is not currently common in the North Umpqua area, but it presents a serious risk of spreading rapidly post-burn.

Post-fire management activities may also impact riparian areas by spreading weeds via salvage logging activities and clearing hazard trees along roadsides. Significant salvage logging activities are occurring in the Rock Creek drainage in particular, and there are relatively high traffic levels on Rock Creek road.

Debris flows are also a concern within creeks and drainages. Although flows could provide some benefits, such as introducing large wood into streams, they can also cause additional mortality to the remaining vegetation and create high-turbidity conditions damaging to aquatic life.


**100% tree mortality and salvage logging operations (left) and rapid regeneration of Canada thistle in burned area (right) both within the Rock Creek watershed.**

## Forestry/Private Timber Lands

The vast majority of the area assessed in this report is comprised of commercial forestry operations. Close to 100% tree mortality is the norm in these areas, with soil burn severity generally moderate to high. Common conifer species in these areas – western hemlock and Douglas fir—are not capable of surviving medium or high severity burns. There is no expectation that these stands will reforest quickly and naturally with conifers. Instead, these areas are more likely to recruit primarily red alder and bigleaf maple to a lesser extent. Bigleaf maple is only moderately fire-resistant, and while most observed trees appeared dead, many were sprouting from living rootstock in areas where soil burn severity was moderate. Some suppression of conifer establishment by competing vegetation is expected unless active management measures are taken. Very few understory species will have survived medium and high-intensity burns. Still, species such as vine maple (*Acer circinatum*), can thrive in the sun or shade and are typical pioneers of both burned and recently logged areas.

As in other areas, common weeds are likely to take advantage of exposed soil. Existing populations of Armenian blackberry, Canada thistle, and Scotch broom are likely to spread unless managed. Scotch broom seeds are long-lived (50-70 years) and will likely germinate heavily in post-fire conditions (Bossard 2000).

### Wetlands/wet meadows

Although less common than forested wetlands and, several open, emergent wetlands are present, especially near Rock Creek Road. Seasonally wet meadows, like prairies, may have a positive to low-intensity fire. However, compositional changes to wet meadow plant communities due to fire suppression, invasive species, and grazing, can mean that merely reintroducing fire may not replicate historical conditions (Bartels and Wilson, 2001). In contrast, the response of heavily inundated palustrine wetlands to fire in the western cascades is not well documented. Field visits demonstrated that previously emergent wetlands are showing signs of a recovering plant community where burned over, with regrowing small-fruited bullrush and slough sedge. Compositional changes of wetlands may occur and should be monitored, such as the conversion of forested wetlands to open emergent communities as hardwoods such as red alder and willows experienced heavy canopy mortality. In all cases, increased sunlight and bare ground represent a risk of weed introduction. Common teasel is relatively frequent in wet areas along roadsides, and seeds may quickly spread into wet areas. Sedimentation due to landslides and erosion is also a concern given the extreme vegetation mortality on slopes above wetlands. Degradation of wetlands due to these factors could have severe consequences for both water quality and stormwater retention, especially within the Rock Creek watershed.

### Fire Suppression Activities

Seventy-eight miles of new containment lines were created during fire suppression activities, the majority of which were created by dozer, with some hand lines in steep or otherwise inaccessible areas. An additional 51 miles of roads were used as suppression lines, and vegetation was removed alongside these roads. All fire lines represent disturbance and bare mineral soil, creating potential pathways for weed introduction and are included in the GIS model. Finally, 34 fire suppression points of varying sizes were created, representing helicopter landing zones and drop points.

## 1.5. Risk Assessment

### 1.5.1. IMPACTS OF INVASIVE SPECIES ON THE LANDSCAPE

The damage of invasive plant infestations would have considerable long-term effects with an eventual displacement of native plants. Using the risk matrix found on pg. 13, risk categories were assigned to describe the threat to critical values. Full Values at Risk Table can be found in Appendix B. The risk is moderate to major in magnitude with a relatively high probability of damage or loss for the following reasons:

1. Reduction in habitat value due to competition from invasive plants spreading into previously native-dominated areas, either via fire suppression activities or post-fire infrastructure repair and salvage logging operations.
2. Reduction in economic productivity (grazing and timber production) of burned areas due to invasive species competition with native communities.
3. Decreased slope stability due to increased cover by shallow-rooted invasive species leading to erosion and reduced water quality.
4. Loss of rare or important plant communities and rare and endemic species due to increased

### 1.5.2. RESPONSE ACTIONS CONSIDERED

Weed treatments, including Early Detection and Rapid Response (EDRR), were considered to rehabilitate and recover the Archie fire burn areas. This may include the use of herbicides, biocontrols, and in rare cases, mechanical methods. Rehabilitation of burned and disturbed areas via seeding and planting was also considered in some cases.

Response actions considered include the following:

- Surveying and manual/mechanical/herbicide treatments of roadsides (EDRR)
- Surveying and manual/mechanical/herbicide treatments of natural vegetation protection areas (EDRR)
- Utilization of biological controls to treat noxious weeds (EDRR)
- Re-establishing vegetation on bare ground in high-risk areas including along roadways and fire suppression lines.
- Using only native, certified weed-free seed mixes when revegetation is necessary
- Applying native plantings to high-value vegetation protection areas, including the Rock Creek riparian area.
- Establishing vehicle wash stations for salvage logging operations operating via Rock Creek road.
- Surveying and manual/mechanical/herbicide treatments of dozer line, staging & drop sites (Suppression EDRR)

## 1.6. Recommended Response Actions

Extensive Early Detection and Rapid Response mapping and treatment of weed populations in all vegetation protection areas shown in the model results section is desirable but given resource limitations, priority should be given to monitoring and treatment of areas with the most potential disturbance and possibility to act as pathways for invasive spread, particularly the Rock Creek road corridor and the fire containment lines. If resources allow, EDRR survey and treatment can extend into other critical habitats/resource protection areas.

Thirty-seven (37) invasive plant species were located within the GIS model's study area. Suggested EDRR target weeds and their general locations are described in Table 4.

**Table 3. Locally Rare and Endemic Plants**

| Species | Common Name | Preferred habitat |
|---|---|---|
| Calochortus umpquaensis | Umpqua mariposa lily | Open meadows on serpentine soils within the Little River drainage. Shade tolerance is low. |
| Romanzoffia thompsonii | Thompson's mistmaiden | Vernally wet seeps on cliffs and rocky slopes. Low shade tolerance. |
| Pellaea andromedifolia | coffee fern | Dry, rocky slopes with high exposure. |
| Horkelia congesta | shaggy horkelia | Wet prairies. |

**Table 4. Priority EDRR Weed Species**

| Species Name | Common Name | Oregon State | General Location |
|---|---|---|---|
| *Brachypodium sylvaticum* | slender false brome | B | Along highway 138, Rock Creek road and Rock Creek riparian areas |
| *Carduus tenuiflorus* | Slender-flower thistle | B | Oak woodlands near highway 138 |
| *Carthamus lanatus* | Woolly distaff thistle | A | Meadows west of main burned area |
| *Centaurea moncktonii* | meadow knapweed | B | Highway 138, possibly other roads within burn (Known populations within Umpqua National Forest) |
| *Centaurea nigrescens* | Tyrol knapweed | B | Steamboat Work Center (BLM, not shown in analysis) |

| Species Name | Common Name | Oregon State | General Location |
|---|---|---|---|
| *Cirsium arvense* | Canada thistle | B | Rock Creek road and surrounding meadows, Likely other areas not surveyed. |
| | | | |
| *Cytisus scoparius* | scotch broom | B | Highway 138, most roads within burn |
| | | | |
| *Dipsacus fullonum* | Teasel | B | Umpqua River corridor, Rock Creek corridor, likely other areas. |
| *Hedera helix* | English ivy | B | Umpqua river corridor |
| *Hypericum perforatum* | St. John's wort | | Most roads within burn |
| *Lathyrus latifolius* | perennial peavine | B | Highway 138,<br>Rock Creek road. |
| *Phalaris arundinacea* | Reed canarygrass | Not listed | Wet areas along western Umpqua river corridor |
| *Rubus armeniacus* | Himalayan blackberry | B | Roadsides throughout burn |
| *Senecio jacobeae* | Tansy ragwort | B, T | Rock Creek Road corridor, oak woodlands on western edge of burn, various roads throughout burn. |
| *Taeniatherum caput-medusae* | medusahead | B | Bluffs above the little river |

### 1.6.1. EDRR TREATMENTS – PROTECTION AREAS

Model results describe 99 acres of high-priority EDRR survey and treatment within non-federal lands – areas with greater than 50% vegetation mortality within 50 meters of points where priority weeds have been observed in previous surveys. A total of 375 acres of EDRR survey and treatment is also recommended in areas with less than 50% vegetation mortality. EDRR survey areas are concentrated within the Rock Creek road corridor and riparian area (central portion of the fire), along Highway 138, and west of the main fire perimeter.

Biocontrol is also recommended for tansy ragwort if suitable populations are located.

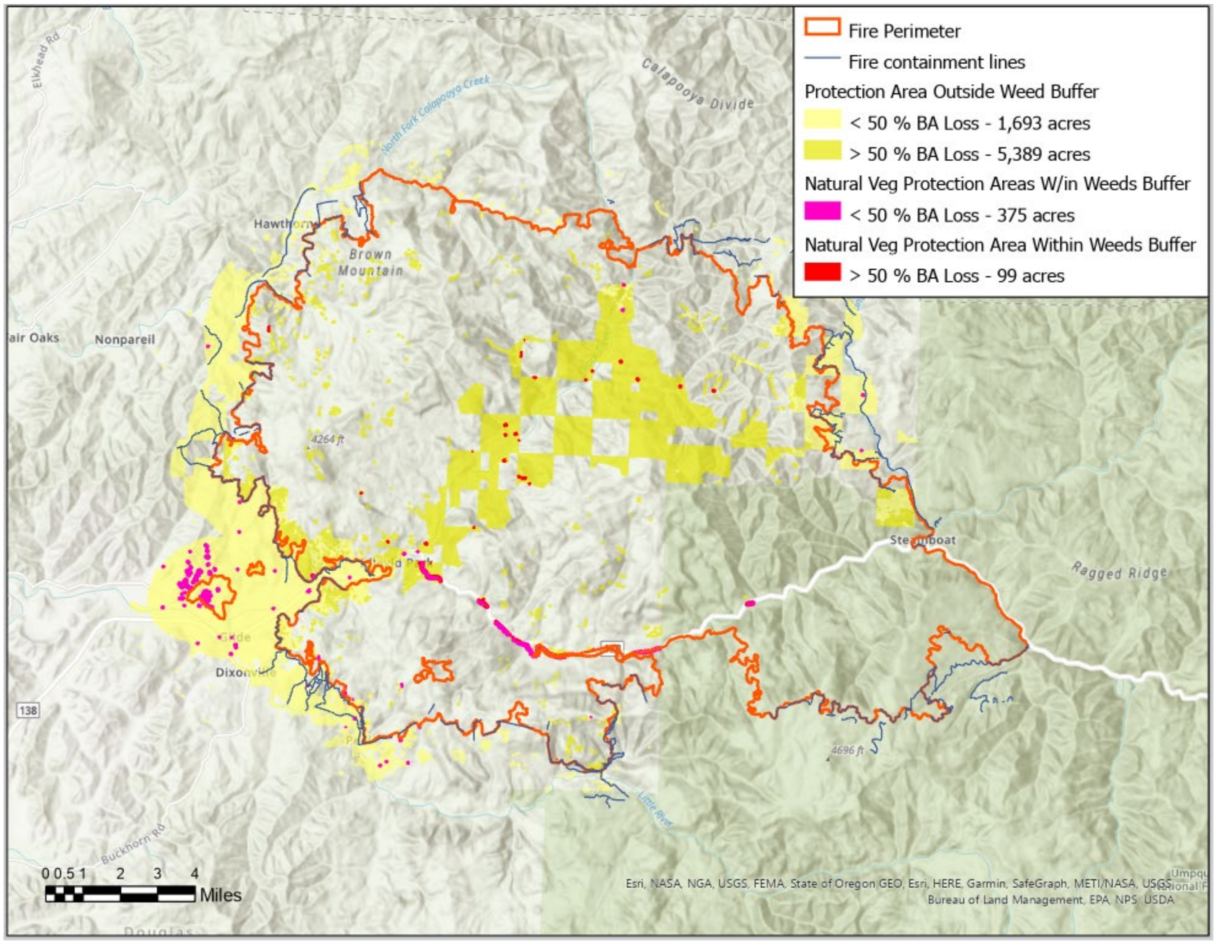


**Figure 3. Natural Resource Vegetation Protection Areas and Recommended EDRR Treatments**

### 1.6.2. EDRR TREATMENTS – SUPPRESSION AREAS

A total of 128 miles of fire suppression/containment lines were created during fire control efforts, including hand lines, dozer lines, and vegetation removal along roads. The majority of these areas lie outside of the burn perimeter. Ideally, EDRR survey and treatment would be completed for all suppression areas. However, if funds are limited, prioritization should be given to areas with the highest burn severity since there will be less chance of quick native vegetation recovery without intervention.

**Table 5. Suppression Lines by Type and Burn Severity**

| Category | Burn Severity | Acres |
|---|---|---|
| Completed Dozer Line | Outside fire perimeter | 38.2 |
| Completed Dozer Line | High | 0.1 |
| Completed Dozer Line | Low | 3.9 |
| Completed Dozer Line | Moderate | 2.0 |

| Category | Burn Severity | Acres |
|---|---|---|
| Completed Dozer Line | Unburned | 3.8 |
| Completed Hand Line | Outside fire perimeter | 0.9 |
| Completed Hand Line | Low | 0.1 |
| Completed Hand Line | Moderate | 0.0 |
| Completed Hand Line | Unburned | 0.3 |
| Road as Completed Line | Outside fire perimeter | 31.1 |
| Road as Completed Line | High | 0.0 |
| Road as Completed Line | Low | 1.3 |
| Road as Completed Line | Moderate | 0.4 |
| Road as Completed Line | Unburned | 5.0 |
| | **Total** | **87.1** |

### 1.6.3. REVEGETATION

Revegetation and restoration efforts are likely to be minor initially. Any seeding that occurs on roadways or in other disturbed areas should be 100% native. Seeding should initially be limited to suppression areas and high-traffic roadways. Seeding even native species in protected areas may hinder the response of existing vegetation, and in areas of rare plants or habitats, may be actively harmful by increasing resource competition. However, seeding of blue wild rye or similar woodland grasses may be useful along fire suppression lines to limit invasive spread given the possibility of equipment already introducing new weed seeds.

Tree planting needs in the Rock Creek and other riparian areas should be assessed after thorough documentation of canopy mortality during the Spring 2021 growing season. Planting efforts, if required, can then be targeted for winter 2021/2022.

### 1.6.4. RECOMMENDED TREATMENT SCHEDULE AND ASSOCIATED COSTS

Given the terrain and the unknown density of weed populations post-burn, it is likely that most weed treatments, with the exception of roadsides, will be done via foot and handheld/backpack sprayer. Access for mechanized equipment is limited, although it may be useful in some cases. For purposes of efficiency and to target weeds during the first growing season, it may be useful to have fully-equipped spray crews perform the surveys and treat on the spot if conditions and timing are appropriate. The approximate cost of recommended treatments is shown in table 6 – note that these costs are based on rates for contractors in the Portland and Salem region and may differ locally. Costs do not also include direct supervision and training of EDRR crews, which may be needed.

## 1.7. Best Management Practices Recommendations

Control of targeted noxious weeds should use established Best Management Practices (BMPs) to improve control and minimize impacts to non-targets. Below is a list of recommended resources for BMP.

- 4-County CWMA Best Management Practices: https://4countycwma.org/aweeds/best-management-practices/
- Columbia Gorge CWMA Best Management Practices: https://columbiagorgecwma.org/weed-listing/best-management-practices/
- DiTomaso, J.M., G.B. Kyser, *et al.* 2013 *Weed Control in Natural Areas in the Western United States*. Weed Excerpts [online], Weed research and Information Center, Davis, CA: University of California, Davis. https://wric.ucdavis.edu/information/natural%20areas/natural_areas_scientific_A-B.htm
- Peachey, E., editor. 2020. Pacific Northwest Weed Management Handbook [online]. Corvallis, OR: Oregon State University. http://pnwhandbooks.org/weed.

## 1.8. Recommended Monitoring

Initial post-fire assessments should be made in the spring of 2021. This can be conducted simultaneously with EDRR surveys. Monitoring protocols should be designed to monitor changes to site conditions over time and occur during the growing season.

A permanent photo point should be established, representing a mix of the habitats and categories represented in the Critical Values Table. Quantitative monitoring of changing plant communities could be useful but may not be feasible given the affected area's scale. During visits to photo points, general qualitative notes on species present and relative abundance are essential to document changing conditions. Annual monitoring visits should also consider whether new factors impact plant communities, such as landslides, grazing, road maintenance, etc.

Monitoring should occur for at least 3, but ideally 5-10 years post-fire. Monitoring for two years after the final treatment of EDRR weed species will help document whether treatments are effective.

### Acknowledgements

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Kathy Pendergrass, Natural Resource Conservation Service
Joel Price, Oregon Department of Agriculture
Carri Pirosko, Oregon Department of Agriculture
John Runyon, Cascade Environmental Group
Wyatt Williams, Oregon Department of Forestry

## 1.9. References


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9. FEIS (Fire Effects Information System) https://www.feis-crs.org/feis/

10. Oregon State Weed Board 2019 (https://www.oregon.gov/ODA/programs/Weeds/Pages/WeedBoard.aspx)

11. Oregon Dept. of Forestry, "Oregon Habitat Conservation Plan Initiative," 2020. https://www.oregon.gov/odf/aboutodf/Pages/HCP-initiative.aspx.

12. Oregon Department of Fish and Wildlife, "Oregon Conservation Strategy," 2016. https://www.oregonconservationstrategy.org

13. USDA Forest Service NRIS database 2020.

# 2. Engineering Report

## 2.1. Objectives

Field investigations of existing roads within the boundaries of the Archie Fire located on non-federal forest land occurred from October 30th-November 9th, 2020. These investigations only occurred on non-Forest Service portions of the fire.

The purpose of the engineering investigation was to assess potential negative effects on roads, culverts and other hydraulic structures attributable to the post-fire condition of the watersheds. The investigation also looked at those safety and warning structures required to provide safe passage of motorists accessing the public lands on authorized roads within the burn area. This report will provide a general summary of the values at risk, observations and findings, and recommendations resulting from the investigation.

## 2.2. Values at Risk

The watersheds burned within the Archie Fire will experience increased runoff, sediment/ash laden flows, and debris flows. Increased flows may cause the capacity of drainage features to be exceeded and transported sediment and debris may cause culverts and other drainage features to fail. These impacts may cause uncontrolled flow across the road prism causing damage and potential failure. The road prism may become impassible to vehicles and in extreme cases may be completely washed out due to fill slope failure. Road prisms may also be damaged due to falling rock, tree and any other debris making the road impassible. This report identifies roads and structures that will be impacted by post-fire debris flows and flooding, evaluates their current condition and vulnerability, and considers treatments to minimize the risks to safety, infrastructure, and the potential for increased post-fire runoff. The following table describes the threats to various resources and the assigned risk value determined during this assessment.

**Table 1. Values at Risk Table**

| Critical Value | Risk | Value Category | Threat |
|---|---|---|---|
| County road infrastructure | Low | Property | Damage to existing infrastructure from increased runoff, erosion, and debris flows |
| General Public including residents, recreationists, commercial traffic, and anyone wishing to access private and public land within the fire area. | Low | Human Life & Safety | Falling trees, road damage and loss of egress. Access to upper watersheds could pose a safety issue. |

## 2.3. Observations

The Archie Fire contains a variety of jurisdictions and private landowners that are responsible for the roads within the fire perimeter. The roads that were observed during this investigation are primarily the responsibility of Clackamas County road department with a minority of other roads under the control or ownership of private forest landowners or residents. These roads are all located on the western edge of the fire and fell within the low burn severity with a sections of moderate burn severity. None of the roads evaluated pose little to no concern for failure due to the lack of high burn severity near them.

## 2.4. Reconnaissance Methodology and Results

Roads were prioritized based on limited resource time. All roads driven had little investment or infrastructure and minimal drainage control.

A total of approximately 8.75 miles of county and private roads within or adjacent to the fire perimeter were examined in detail by ETART Engineering specialists. The following roads were identified of having a risk to property or human life or safety.  Other roads within the fire perimeter that were assessed did not pose any potential risks to property or human lifer and safety.

| Road Name or # | Jurisdiction | Total Miles | Mileage within the burn |
|---|---|---|---|
| Bar L Ranch Road | Douglas County | 2.64 | 2.42 |
| Doe Road | Douglas County | 0.27 | 0.27 |
| Lone Rock Road | Douglas County | 2.93 | 1.42 |
| Kimmel Lane | Douglas County | 0.31 | 0.33 |
| Skyview Drive | Douglas County | 0.4 | 0.4 |
| Rock Creek Road | Douglas County | 1.45 | 1.45 |
| Anabel Road | Douglas County | 1.00 | 1.00 |
| Evergreen Drive | Douglas County | 0.72 | 0.72 |
| Smith Springs Lane | Douglas County | 0.74 | 0.74 |

The results of the field investigations identified risks to human life and safety due to the hazards associated with the fire adjacent to roads and property due to unmitigated hazard trees falling onto a public road and during heavy rainfall events the potential for culvert and road failures.

## 2.5. Findings

The roads observed on non-federal lands pose little threat due to their location within the fire and minimal damage observed. These roads will require minimal action to remain open and safe.

| ROAD | DESCRIPTION & ISSUES |
|---|---|
| Bar L Ranch Road | ▪ Unpaved self-maintaining private road<br>▪ Provides access to numerous rural residential dwellings.<br>▪ Connects to additional county road: Doe Road<br>▪ **Needs:** storm monitoring and ditch cleaning of all culverts, 3 culvert inlet repairs, 1 culvert replacement<br>▪ Critical values at risk – (property) |
| Doe Road | ▪ Unpaved self-maintaining private road<br>▪ Provides access to numerous rural residential dwellings.<br>▪ Connects to additional county road: Bar L Ranch Road<br>▪ **Needs:** storm monitoring and ditch cleaning of all culverts<br>▪ Critical values at risk – (property) |
| Lone Rock Road | ▪ Paved self-maintaining county road<br>▪ Provides access to numerous rural residential dwellings and private forestland, large tracts of BLM land.<br>▪ **Needs:** storm monitoring and ditch cleaning of all culverts<br>▪ Critical values at risk – (property) |
| Kimmel Lane | ▪ Unpaved self-maintaining private road<br>▪ Provides access to numerous rural residential dwellings.<br>▪ **Needs:** storm monitoring and ditch cleaning of all culverts<br>▪ Critical values at risk – (property) |
| Skyview Drive | ▪ Paved self-maintaining county road<br>▪ Provides access to numerous rural residential dwellings.<br>▪ **Needs:** storm monitoring and ditch cleaning of all culverts<br>▪ Critical values at risk – (property) |
| Rock Creek Road | ▪ Paved self-maintaining county road<br>▪ Provides access to numerous rural residential dwellings and private forestland, large tracts of BLM land.<br>▪ Connects to additional county road: Anabel Road<br>▪ **Needs:** storm monitoring and ditch cleaning of all culverts and repair of several culvert inlets<br>▪ Critical values at risk – (property) |

| ROAD | DESCRIPTION & ISSUES |
|---|---|
| Anabel Road | ▪ Unpaved self-maintaining road (half county, half private)<br>▪ Provides access to numerous rural residential dwellings.<br>▪ Connects to additional county road: Rock Creek Road<br>▪ **Needs:** storm monitoring and ditch cleaning of all culverts and repair of at least 3 culverts<br>▪ Critical values at risk – (property) |
| Evergreen Drive | ▪ Unpaved self-maintaining private? road<br>▪ Provides access to numerous rural residential dwellings.<br>▪ **Needs:** storm monitoring and ditch cleaning of all culverts and 1 culvert replacement<br>▪ Critical values at risk – (property) |
| Smith Springs Lane | ▪ Unpaved self-maintaining private? road<br>▪ Provides access to a few rural residential dwellings.<br>▪ **Needs:** monitoring of log jams in North Umpqua River which can cause flooding and bank erosion<br>▪ Critical values at risk – (property) |

## 2.6. Recommendations

### 2.6.1. EMERGENCY STABILIZATION

Emergency stabilization treatments should be implemented as quickly as possible to protect human life and safety and minimize the negative impacts of other critical values.

#### Storm Patrols

The roads at risk that were assessed within the Archie Fire burned areas that are primarily located within or below areas of Low to Moderate burn severity. There is a future threat to travelers along the roads within the burned area due to the increased potential for culverts plugging with sediment or debris which could washout sections of the roads. With the loss of vegetation, normal storm frequencies and magnitudes can more easily initiate erosion on the slopes, and it is likely that this runoff will cover the roads or cause washouts at drainage facilities (culverts) or stream crossings. These events make for hazardous access to forest roads and put the safety of users at risk.

Coordination should occur with all the agencies with public access roads within the fire perimeter including USFS, Douglas County, PacifiCorp, and ODOT.

**Recommendation:** Monitor road drainage structures and debris flow treatment structures after significant storm events to ensure the maximum drainage capacity is maintained until the natural re-vegetation of the burned area has occurred. Maintain and/or repair any damage to road surfaces.

Remove sediment and debris from drainage and treatment structures and repair any headcutting in streams and drainages to prevent further degradation of channels adjacent to roadways. Monitor the movement of large woody debris and make a determination of whether or not the material should be removed before it contacts bridge piers, abutments, or culverts.

See Burned Area Emergency Response Treatments Catalog Chapter 4, Storm Inspection and Response pg. 149 -152 and BAER Specification for Storm Patrols for more information.

Continue storm inspection and response until vegetation has reestablished in affected watersheds or for at least a total of two years.

### 2.6.2. CULVERT REPLACEMENT

Currently 1 culvert crossings where the culvert burned up with moderate burn drainages above on Bar L Ranch Road. The void left by the culvert is currently functioning but will erode rapidly and will undermine the road if not replaced soon. Other culverts in the burn area should be monitored to ensure full functionality through storm inspection and response.

Several culverts are damaged and need repair or replacement in order to function properly.

**Recommendation (Bar L Ranch Rd.):** Replace culvert within 1 year to ensure there is no risk to road.

**Recommendation (Other culverts in burn area):** If feasible and cost effective to replace the culverts to handle the post fire flows, proceed with full culvert replacement. If culvert is not replaced, proceed with monitoring and ditch cleaning along the roads identified in the report.

### 2.6.3. PROPOSED ENGINEERING TREATMENTS

For cost estimates, please see Appendix A.

| Bar L Ranch Road |
| --- |
| Storm monitoring and ditch cleaning of all culverts, 3 culvert inlet repairs, and 1 culvert replacement. |

| Doe Road |
| --- |
| Storm monitoring and ditch cleaning of all culverts. |

| Lone Rock Road |
|---|
| Storm monitoring and ditch cleaning of all culverts, 2 culvert inlet repairs. |

| Kimmel Lane |
|---|
| Storm monitoring and ditch cleaning of all culverts. |

| Skyview Drive |
|---|
| Storm monitoring and ditch cleaning of all culverts. |

| Rock Creek Road |
|---|
| Storm monitoring and ditch cleaning of all culverts, 2 culvert inlet repairs. |

| Anabel Road |
|---|
| Storm monitoring and ditch cleaning of all culverts, 2 culvert inlet repairs, and 1 possible culvert replacement. |

| Evergreen Drive |
|---|
| Storm monitoring and ditch cleaning of all culverts and 1 possible culvert replacement. |

| Smith Springs Lane |
|---|
| Storm monitoring and ditch cleaning of all culverts. |

## 2.7. References

Burned Area Emergency Response Treatments Catalog December 2006 National Technology & Development Program Watershed, Soil, Air Management 0625 1801-SDTDC

Cost Estimating Guide for Road Construction March 2012 USDA Forest Service Intermountain, Southwestern, Rocky Mountain Regions

# 3. Heritage and Cultural Resources

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Heritage BAER Assessment Lead, Archaeologist, AD-COIDC (Deschutes & Ochoco National Forests)

ETART (Erosion Threat Assessment and Reduction Team) is a process used by FEMA in partnership with other federal lands management agencies to assist state, local governments and private land owners in preventing post-fire threats to human life and safety as well as protecting critical natural and cultural resources on state and private lands. The Forest Service and the BLM have similar procedures to address post-fire effects for national forest and public lands which are known as BAER (Burned Area Emergency Response) and ES (Emergency Stabilization) respectively. ETART is deployed following devasting wildfires once the Governor has declared a state of emergency and FEMA is deployed to assist by the Department of Homeland Security.

The goal of the ETART process for the four large fires in Oregon during the devasting 2020 wildfire season was to form a team of BAER/ES and other resources specialists who would train and supervise state and local specialists to conduct the critical value analysis. The ETART assessment for cultural resources is a high-level look at the potential for post-fire erosion, debris flows and exposure of critical cultural resources in the non-federal portions of the Archie Creek fire. It is not meant to be an assessment of each cultural resource site, but an overall look at the vegetation burn severity on or adjacent to cultural resources and sites of tribal significance.

Unfortunately for the Archie Creek Fire in western Oregon, no state or local cultural resource specialists volunteered or were otherwise made available for this effort. In addition, the acquisition of sensitive cultural resource GIS (feature data classes) from the Oregon SHPO for state and private lands in the fire area was not possible. This was due to the team's inability to secure a data sharing agreement in the timeframe allotted. Thus, a fine-grained analysis of site locations as compared to moderate to high burn severity in the fire area could not be performed.

Given the lack of cultural resource personnel and completion of a critical values analysis, we recommend that FEMA, State and local agencies seek to acquire GIS data on archaeological and historic sites directly with Oregon SHPO and then apply the ETART process to determine the cultural resource critical values, perceived risks and propose treatments where the likelihood of success is greatest. What follows are some general guidelines for addressing values, risks and treatments.

## 3.1. Setting

The Archie Creek Fire originated on September 8, 2020 and burned approximately 131,542 acres. The soil burn severity on state and private lands was Moderate on 31,366 acres, and High On 20,867 acres.

**Table 1: Soil Burn Severity Acreage by Ownership**

| Soil Burn Severity | Forest Service | BLM | State | Private | Total | % within the Fire Perimeter |
|---|---|---|---|---|---|---|
| Unburned | 2,980 | 4,198 | 0 | 4,514 | 11,692 | 9 |
| Low | 4,360 | 6,381 | 29 | 7,911 | 18,681 | 14 |
| Moderate | 11,971 | 14,564 | 10 | 31,356 | 57,901 | 44 |
| High | 7,111 | 15,273 | 0 | 20,867 | 43,251 | 33 |
| **Total** | **26,422** | **40,415** | **39** | **64,648** | **131,524** | **100** |

Burn classifications are as follows:

**Unburned** – Little to no burn expected within these areas. Canopy and ground litter completely intact. Little to no vegetative mortality expected.

**Low** - The ground surface, including any exposed mineral soil, may appear lightly charred, and the canopy and understory vegetation will likely appear green.

**Moderate** - Up to 80 percent of the pre-fire ground cover may be consumed but generally not all of it. There may be potential for recruitment of effective ground cover from scorched needles or leaves remaining in the canopy that will soon fall to the ground. Soil structure is generally unchanged.

**High** – All or near all pre-fire ground cover and surface organic matter is generally consumed, and charring may be visible on larger roots. Soil is often gray, orange, or reddish at the ground surface where large fuels were concentrated and consumed.

## 3.2. Background

Wildfires have the potential to damage or destroy non-renewable cultural resource sites through a variety of processes, including effects from burning and smoke damage, fire suppression actions, soil movement caused by subsequent storm precipitation, such as gullying and rilling, and the implementation of suppression rehabilitation and ETART treatments. Cultural resources with fire sensitive or combustible components are most susceptible to direct fire effects. Additional direct fire effects include suppression activities such as the construction of dozer and hand lines, safety zones, helispots, contingency lines and drop points on or immediately adjacent to surface or subsurface cultural resource deposits. Indirect fire effects have the potential to impact a greater number of cultural resources over a longer period of time. Indirect effects may include erosional threats, visibility and accessibility threats that could invite unauthorized removal (looting), and hazardous fuel loading/fire-killed tree falling threats.

The objectives of the assessment are to: (1) identify critical cultural resource values, and (2) propose treatments and measures to prohibit any predicted immediate post-fire effects from fire-related erosion, debris flows, and rehabilitation treatments. Critical cultural resource values typically include historic properties, archaeological sites and sites or areas of Traditional Cultural Values or Sacred Sites as identified by resident traditional communities or groups, such as Federally recognized and non-recognized Indian Tribes.

Not all cultural resource sites should be considered under the ETART process, rather a triage process is deployed to fine-tune which sites are critical, have risks and warrant treatment. Ideally a small group of specialists, including representatives of interested tribes should prioritize the site inventory to reflect (in order of value) sites listed on the National Register of Historic Places (NHRP), sites determined as eligible to the (NRHP), and sites identified as having traditional cultural or spiritual values to tribes or other ethnic groups. Cultural resource sites that are designated as unevaluated are generally not considered under ETART, unless their value is exceptional and would likely be easily determined eligible or listed on the NRHP. Cultural resource sites are categorized into 4 broad types: precontact ("prehistoric") sites, historic sites, traditional cultural properties and Indian Sacred Sites. These are further distinguished by whether they are "above ground" structures (historic properties) or surface and buried archeological sites. A precontact site is one that was established, used and occupied prior the advent of a continuous written record. A historic site postdates this time.

A traditional cultural property is a defined locality that is associated with the cultural practices or beliefs of a living traditional community, is rooted in that community's history, and is important in maintaining the continuing cultural identity of the community. Indian Sacred Sites represent areas which hold special and sacred attachments by a Native American religion or religious practitioners.

Prehistoric and historic sites and traditional cultural areas that are eligible for listing to the National Register of Historic Places (NRHP) are considered historic properties under the National Historic Preservation Act (NHPA) and are managed and protected under that law. Cultural resource sites for which NRHP eligibility has not yet been determined are managed as historic properties until that determination is completed. The most significant and/or endangered historic properties are identified as priority heritage assets (PHAs) and are proactively monitored and managed.

The goal in performing a post-fire ETART assessment allows for the site-specific identification of threatened critical value cultural resources and provides an opportunity to recommend stabilizing treatments that may mitigate short term post-fire effects to critical value cultural resources. GIS data on soil burn severity, debris flows, other potential hazards are necessary from which to assess risks. Objectives of this assessment are as follows:

1. Identify previously documented cultural resources located on state and private lands within the fire that may be at risk.
2. Determine which cultural resource sites contain critical values that may be subjected to immediate threats from post-fire effects.

3. Assess effects of soil burn severity to critical value cultural resources, as well as the potential for indirect, post-fire effects on cultural resources.
4. Apply the BAER Risk Matrix to Critical Value cultural resources to determine which sites should be considered for treatment options.
5. Propose specific BAER treatments for critical value cultural resource sites in jeopardy, in order to prevent and mitigate future damage to cultural resources determined "eligible" or "potentially eligible" for listing on the National Register of Historic Places (NRHP), per criteria in 36 Code of Federal Regulations (CFR) 60.4.

## 3.3. Critical Values and Proposed Treatment for Cultural Resources on NFS lands under BAER.

The USFS lands within the Archie Creek Fire were also subjected to a post-fire assessment process. The USFS BAER team archaeologists identified a total of nine sites with critical values. Of these they proposed treatments on 5 pre-contact and historic sites consisting of seeding, administrative closure of access roads, camera surveillance, directional felling of trees and effectiveness monitoring. They further recommended monitoring of the four remaining sites to track changed condition and potential damage from looting and vandalism.

## 3.4. Assessment Methodology

It is recommended that the following process be used to identify critical values, assess risks and recommend treatments. Ideally, this effort is performed by a small group of cultural resource specialists and tribal representatives knowledgeable about the fire area. The analysis process should begin with a review of the Oregon State Historic Preservation Office (SHPO) geodatabase of archaeological sites and historic structures (feature data classes). Once the "triage" process as described above for determining which cultural resources should be considered as critical values then the focus can shift to geospatial analysis. Using geo-spatial software (ArcGIS), archaeological and historic sites are overlaid with the fire's Soil Burn Severity map. Site locations that fall within high and moderate burn severity should be prioritized for field assessment if possible, as well as sites at risk from falling snags, flooding, or other post-fire conditions likely to adversely affect cultural resources. Since field assessments may not be feasible the initial findings of this analysis should be reviewed by a select group of cultural resource and tribal specialists for review. Based on their input a decision can be made to concentrate on sites of greater significance (critical values), such as those listed or eligible for the NRHP, sites with tribal values and those that are likely candidates for future eligibility or listing.

Once a select set of cultural resource sites of critical value are determined then the group shifts their focus to determining the level of risk and the magnitude of consequences using the table below for guidance.

| Probability of Damage or Loss | Magnitude of Consequences | | |
|---|---|---|---|
| | Major | Moderate | Minor |
| **Very Likely** | Very High Risk | Very High Risk | Low Risk |
| **Likely** | Very High Risk | High Risk | Low Risk |
| **Possible** | High Risk | Intermediate Risk | Low Risk |
| **Unlikely** | Intermediate Risk | Low Risk | Very Low Risk |

**Figure 6. Risk Matrix**

Probability of Damage or Loss: The following descriptions provide a framework to estimate the relative probability that damage or loss would occur within one to three years (depending on the resource):

- Very likely - nearly certain occurrence (>90%)
- Likely - likely occurrence (>50% to < 90%)
- Possible - possible occurrence (>10% to <50%)
- Unlikely - unlikely occurrence (<10%)

Magnitude of Consequences:

- Major - Loss of life or injury to humans; substantial property damage; irreversible damage to critical natural or cultural resources.
- Moderate - Injury or illness to humans; moderate property damage; damage to critical natural or cultural resources resulting in considerable or long-term effects.
- Minor - Property damage is limited in economic value and/or to few investments; damage to natural or cultural resources resulting in minimal, recoverable or localized effects.

In determining the magnitude of consequences, it is important to consult with other natural resource specialists and engineers to help determine if the probability of damage or loss of significant cultural resource properties or their cultural and data/informational values.

Once the magnitude of consequences is determined to fall under the red shaded cells in the matrix above then treatment options should be considered, developed, costed out in consultation with land managers, engineers and other resource specialists with knowledge and skills in point protection from flooding and debris flows, windfall or exposure. For critical value cultural resource sites newly exposed and vulnerable to unauthorized artifact removal consider temporary access closures, and mulching or slash dispersal to deter theft.

To summarize, the ETART assessment process should:

- Determine if any critical values exist; e.g. Sites listed on the National Register or that have been determined to be eligible for the NRHP, sites important to local Tribes (based on consultation with the Tribes) within the fire perimeter
- Determine if critical value sites are located within areas of high/moderate burn intensity
- Apply the Risk Matrix to determine if any sites area at risk to post-fire effects
- Propose treatments to reduce risks, treatments should have a high likelihood of success
- Monitor the effectiveness of treatment for this and future fires on state or private lands

# 4. Soil Resources

Brooke Hogan, Natural Resources Conservation Service

## 4.1. Summary

### 4.1.1. OBJECTIVES

The objectives of this assessment are as follows:

- Validate the Forest Service-produced Soil Burn Severity for State and Private lands
- Identify risks to human health and safety, property, and infrastructure from increased erosion in the post-fire environment

This assessment will describe changes to soil caused by fire and discuss threats to critical values from increased erosion, suspended sediments, and debris flows in the post-fire environment.

### 4.1.2. CRITICAL VALUES

Critical values are areas where there is clear risk to human health/safety, property, infrastructure, water quality, etc. In the Archie Creek burn area, the following critical values were identified:

- Beaty Creek
- Hinkle Creek
- Honey Creek & nearby residence
- Harrington Creek & Harrington Creek Bridge
- Kelly Creek
- McComas Creek
- Rock Creek Fish Hatchery
- East Fork Rock Creek Tributary

## 4.2. Resource Condition and Setting

### 4.2.1. CLIMATE

The climate of the burn area follows a Mediterranean climate pattern. Winters are typically cool and wet, and summers are hot and dry. The area averages 40 to 101 inches of rain annually. The burn area is divided between two hydroregions. 44% falls below 2100 feet, in the region where precipitation is primarily rain with rare snow accumulation. 1% falls at elevations above 4000 feet where snow accumulation is common. The other 55% lies in a transitory zone between 2100 and 4000 feet where snow accumulates occasionally in the winters.

### 4.2.2. TOPOGRAPHY, GEOLOGY, AND SOILS

Within the Archie Creek Fire volcanic rock, tuff, welded ash and basalt make up 88 percent of the area. Eleven percent of the area is a mixture of sedimentary and volcanic rock. The soils vary from shallow to moderately deep, extremely gravelly soils on the steeper slopes, to deeply weathered clayey soils, that lie on the whole range of gentle to steep slopes. Please see Appendix C (Table I) for a detailed list of the dominant soils in the burn area.

A quarter (25%) of the fire area has very slopes of 60 to 100 percent or more. Primary concerns on the steep slopes are the potential severe surface erosion and for shallow debris slides. Soil textures are mainly very gravelly to extremely gravelly loams and clay loams.

A third (37%) of the area has moderate slopes of 30 to 60 percent, where surface soil erosion potential is moderate to severe, with gravelly loams and clay loams. The remaining 38 percent of the area has gentle slopes of 0 to 30 percent with low to moderate surface soil erosion potential, with loams, silt loams and clay loams on the surface. About half of the soils in the fire area are moderately to deeply weathered, with clayey subsoils. Within these clayey soils, the main concern is for accelerated slope movement, specifically moderately deep and deep-seated movement, and secondarily for surface soil erosion.

The post-fire conditions can accelerate surface erosion and mass wasting, leading to long-term declines in soil productivity and increased sedimentation. In addition to the complete loss of ground cover and vegetation in much of the fire area, the risk of accelerated erosion and mass wasting is compounded by any low to moderate hydrophobicity in the surface soil horizons. The initial high surface erosion would likely be followed by increased mass movements in subsequent years as roots decay in the fire-killed vegetation. The soil and site productivity would also be affected by the increased spread of noxious weeds and invasive non-native plant species in the burned areas.

In non-fire conditions, slides and slumps along stream channels, road cut bank failures and road fill failures can pose problems due to natural geology and geomorphic processes. Given the loss of the forest canopy and ground cover from the fire, the increased overland flow and increased duration of saturated soil conditions with increased surface erosion, slumps and mass wasting pose higher risks for the stream and road networks. Concentrated soil-laden water and failed soil material can scour channels, intercept roads, plug culverts, and overtop roads, resulting in failed soil prisms and additional scoured stream channels further down the drainage network. The road network consists of roads administered and maintained by both the BLM and private landowners. As roots decay in the fire-killed vegetation, on-going road maintenance over some years would be needed to remove accumulated failed material from road cut banks and fill surfaces, ditches, and culverts.

### 4.2.3. SOIL BURN SEVERITY

The Archie Creek Fire began the morning of September 8, 2020 east of Glide, Oregon near Steamboat Springs before merging with the Star Mountain Fire on September 10, 2020. The fire burned approximately 130,000 acres of private timber land, private communities, and BLM land (Roseburg District), and the North Umpqua Ranger District of the Umpqua National Forest. The distribution of burn severity is visible in Figure 1 and outlined in Table 1.

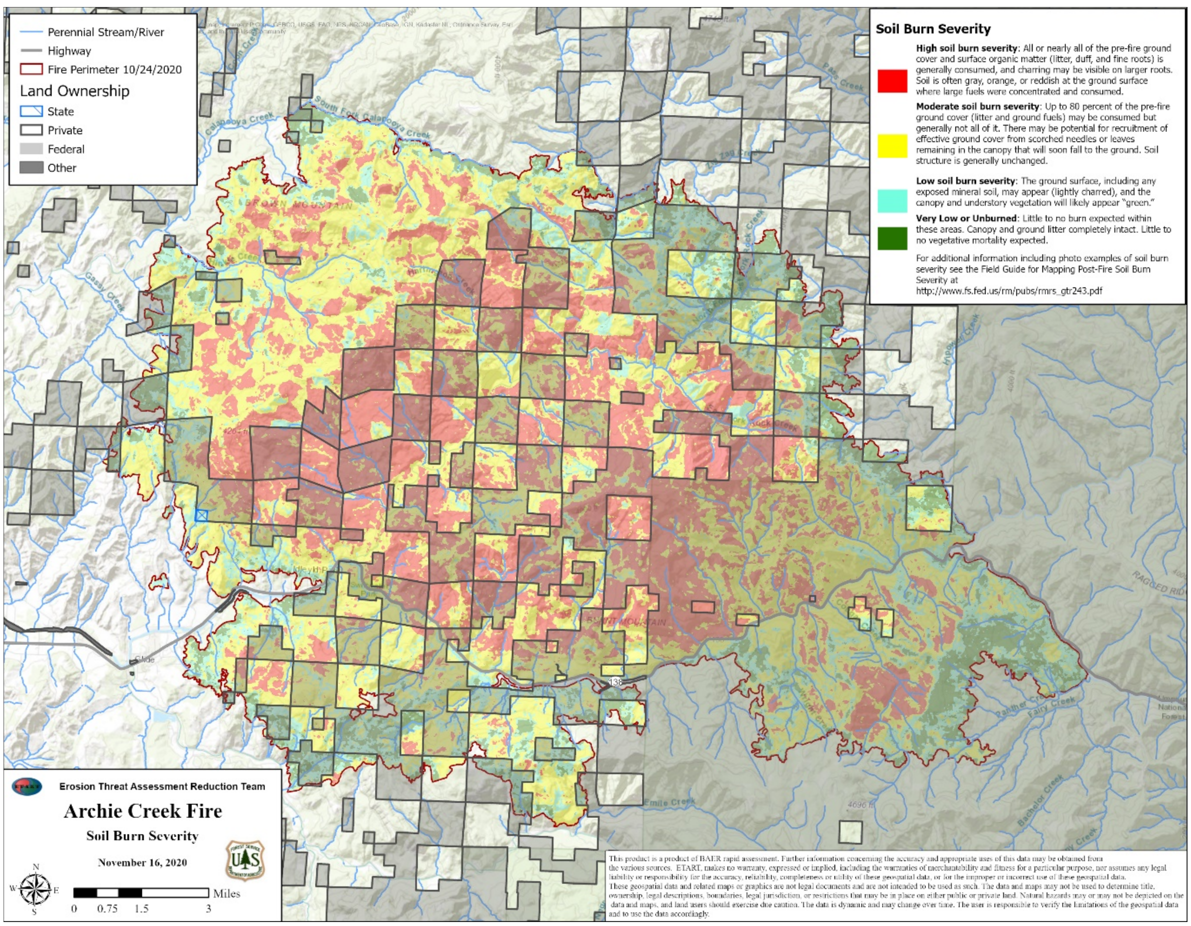


**Figure 1. ETART Soil Burn Severity Map – Archie Creek Fire**

**Table 1. Soil Burn Severity Acreage by Land Ownership - Archie Creek Fire**

| Severity | Acres on State and Private Lands | Acres across All Land Ownerships | Percent of Total Burned Area |
|---|---|---|---|
| High | 20,869 | 43,250 | 33% |
| Moderate | 31,364 | 57,901 | 44% |
| Low | 7,941 | 18,681 | 14% |
| Unburned | 4,515 | 11,692 | 9% |
| **Total** | **64,689** | **131,524** | |

## 4.3. Assessment Methodology

### Burn Severity Field Verification

Burned Area Reflectance Classification (BARC) satellite imagery, aerial reconnaissance data, and field soil burn validation surveys were combined by the Forest Service to create a Soil Burn Severity (SBS) map as a part of the USFS BAER assessment. While the SBS covers all lands within the fire perimeter, previous assessment only validated on-the-ground conditions on federal lands.

ETART field assessments verified the accuracy of the SBS map on state and private lands and assessed critical values at risk. Field assessments were completed using the criteria outlined in the Field Guide of Mapping Post-Fire Soil Burn Severity (RMRS-GTR-243). Partners from the Natural Resources Conservation Service and Forest Service assessed various soil conditions in the field. Soil site assessments included ground cover amount and condition, ash color and depth, soil structure, soil texture, condition of roots, and soil water repellency. Additional site characteristics were assessed, including surface vegetation conditions, canopy vegetation char, and presence of leaf litter or duff and the degree of char or loss. A summary of SBS indicators used are reflected in Appendix C, Table II.

### WEPP Erosion Modeling in Critical Drainages

Changes in soil erosion in each critical drainage were modeled using the Watershed Erosion Prediction Project (WEPP) Disturbed framework. WEPP-Disturbed uses data from various climate monitoring systems, Soil Survey Geographic Database (SSURGO), National Land Cover Database (NLCD), and soil burn severity maps to generate its outputs. In this instance, the gridded surface meteorological dataset (GRIDMET) with Parameter-elevation Regression on Independent Slopes Model (PRISM) revision was used to generate climate variability per hillslope within each drainage.

## 4.4. Findings

### 4.4.1. SOIL BURN SEVERITY

Though the Archie Creek Fire is dominated by moderate and high burn severities on the BARC map, there was little change to the mineral soil in most instances. Soil structure was generally left intact. Roots were affected in some areas, but 100 percent root mortality was rarely observed. Hydrophobicity was variable, but rarely exceeded a moderate rating. However, the soils in the area are naturally disposed to erosion risk, and profound loss of vegetation and ground cover will exacerbate soil erosion. Please see Appendix C, Section II and III, for details about SBS indicators and characteristics unique to the Archie Creek Fire.

### 4.4.2. WEPP EROSION MODELING

Each drainage saw increases in predicted erosion following the Archie Creek Fire. Magnitude of increase was largest across the Rock Creek Tributary near the Rock Creek Fish Hatchery, Harrington Creek, Kelly Creek, and McComas Creek. This is concerning given that these drainages cross main county roads and threaten vital infrastructure.

One significant finding was the relatively dramatic increase in predicted post-fire erosion in the East Fork Rock Creek Tributary. Pre-fire erosion predictions were negligible, but post-fire erosion predictions yield 30 tons/year of hillslope soil loss from the outlet, and 210 lbs/ac/year of hillslope soil loss per unit area in the watershed. Its drainage area is relatively small (290 ac), but severely burned and steep. This may contribute to the dramatic increase in post-fire erosion predictions.

While Hinkle, Beaty, and Honey Creek saw smaller increases in post-fire erosion predictions, they lay near residences (Honey Creek) and/or are mostly or entirely located on private lands (Hinkle and Beaty Creek).

There appears to be a linear relationship between magnitude of increase and percent cover of gravelly soils in each drainage area. A plot of magnitude of increase in erosion versus percent cover of gravelly soils for each drainage was created and a linear regression was performed. The generated linear model has a r-squared value of 0.62819. Ideally, this regression would be done based on a greater scope of data, but this investigation is limited by time and other resources.

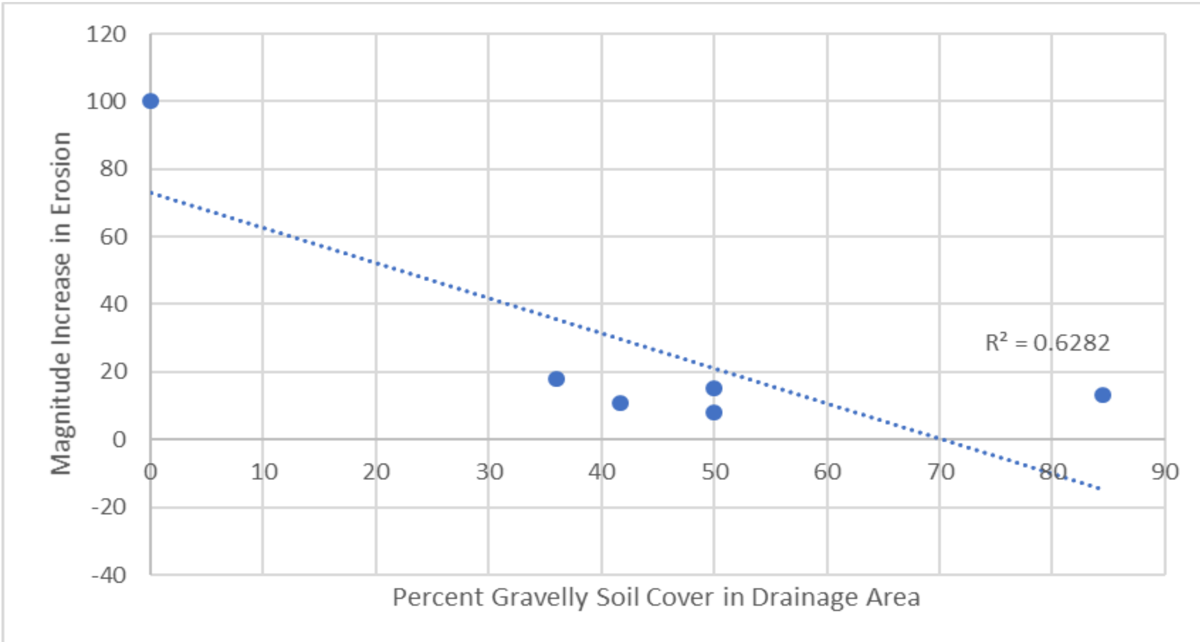


**Figure 4. Plot of magnitude increase in predicted erosion versus percent cover of gravelly soil in drainage area.**

**Table 2. Summary of Modeled Hillslope Erosion for Target Drainages within Archie Creek Fire**

| Drainage Name | Subwatershed | Total Unburned Hillslope Soil Loss from Outlet (ton/yr) | Total Unburned Hillslope Soil Loss per unit area of watershed (lb/acr/yr) | Total Burned Hillslope Soil Loss from Outlet (ton/yr) | Total Burned Hillslope Soil Loss per unit area of Watershed (lb/acr/yr) | Magnitude of Increase |
|---|---|---|---|---|---|---|
| Beaty Creek | Hinkle Creek – Calapooya Creek | 61 | 1100 | 460 | 8600 | 8 |
| Hinkle Creek | Hinkle Creek – Calapooya Creek | 9400 | 2200 | 31000 | 7000 | 3 |
| Honey Creek | Susan Creek – North Umpqua River | 1100 | 730 | 8900 | 5700 | 8 |
| Harrington Creek | Lower Rock Creek | 18 | 140 | 260 | 2100 | 15 |
| Kelly Creek | Lower Rock Creek | 270 | 200 | 3500 | 2600 | 13 |
| McComas Creek | Lower Rock Creek | 480 | 470 | 5500 | 5300 | 11 |
| Rock Creek Trib | Lower Rock Creek | 3.5 | 44 | 66 | 810 | 18 |
| East Fork Rock Creek Trib | East Fork Rock Creek | 0 | 0 | 30 | 210 | undefined |

## 4.5. Risk Assessment

The ETART assessment determined risk to critical values located on state and private lands affected by the Archie Creek fire using the same framework as used by federal BAER teams outlined in the Risk Matrix on Pg. 13. Values within the Archie Creek fire are listed along with the determined risk and recommended treatments in Table 3 in the next section.

## 4.6. Recommendations

All recommended response actions are based on the modeled hillslope soil loss potentials for individual subwatersheds. Recommendations are not meant to serve as site or parcel specific post-fire response plans. The treatment recommendations, outlined in Table 3, for the values identified in the Archie Creek fire burn area are based on several factors including anticipated treatment effectiveness, labor resources, cost effectiveness, etc.

**Table 3. Summary of critical values within the Archie Creek Fire, along with hazard and treatment recommendations**

| Value | Probability of Damage or Loss from Hillslope Erosion | Magnitude of Consequence | Hazard to Value | Treatment Recommendation | Treatment Justification |
|---|---|---|---|---|---|
| Harrington Creek Bridge | Possible | Moderate | Intermediate | Storm Patrol | Confined, narrow drainage may impact bridge footings with post-fire debris |
| Private Property near Honey Creek | Likely | Moderate | Intermediate | Inform of risk | Proximity to alluvial fan will pose higher risk of sediment build up and flooding post-fire, making it an undesirable location for future rebuild |
| Rock Creek Fish Hatchery | Likely | Minor | Low | Inform of risk | Proximity to large drainages and steep, severely burned slopes poses flooding and debris flow risks. |
| Kelly Creek Culvert | Possible | Moderate | Intermediate | Debris removal and storm patrol | Large increases in erosion post-fire will cause increased debris build up. Storm events will exacerbate the issue. |

| Value | Probability of Damage or Loss from Hillslope Erosion | Magnitude of Consequence | Hazard to Value | Treatment Recommendation | Treatment Justification |
|---|---|---|---|---|---|
| McComas Creek Culvert | Possible | Moderate | Intermediate | Storm patrol and upslope stabilization, reinforce bridge footings | Undermined bridge footing is further threatened by erosion post-fire and elevated stream flows; road provides main arterial access to Rock creek |
| Beaty Creek crossing at Road 24-3-33.7 | Unlikely | Minor | Very low | Storm patrol and road maintenance | Low hazard makes more intense treatments less cost effective. |
| Hinkle Creek crossing at Road 24-3-31.1 | Unlikely | Minor | Very low | Storm patrol and road maintenance | Low hazard makes more intense treatments less cost effective. |
| Private residences, county road, and culverts along Bar L Ranch Road | Possible | Moderate | Intermediate | Hazard tree removal and replace culvert on Bar L Ranch Road | Mosaic burn behind homes; one plastic culvert was burned out resulting in damaged road running surface; falling and rolling debris may damage private structures |
| Private residences, county road, and culverts along Evergreen Loop | Likely | Moderate | High | Hazard tree removal and road maintenance | Mosaic burn behind homes with some potential for sediment mobilization and falling or rolling debris. Previous evidence of active erosion and clogged ditch lines make it likely that access will be restricted as sediment and debris moves downhill. |

A full list of post-fire treatments can be found in the United States Forest Service Burned Area Emergency Response Treatments Catalog (0625 1801-SDTDC).

#### 4.6.1. RECOMMENDED MONITORING

Due to the extent of severely burned land and steepness of the burned area, most proactive treatment options will not be effective. For this reason, natural recovery is the best source of action within much of the Archie Creek fire perimeter.

Storm patrols are recommended for major road crossings as rainfall will likely contribute to sudden, large-scale soil erosion and debris sloughing. With the wet season in the burn area quickly approaching, there is not much time for more costly, time intensive treatment options. Storm patrols will not be necessary in remote, infrequently traveled areas. As the burn area naturally recovers, storm patrols will no longer be needed.

# 5. Hydrology Resources

Chris Stevenson, Oregon Department of State Lands
Spencer Higginson, National Weather Service
Kyle Wright, United States Forest Service

## 5.1. Summary

#### 5.1.1. INTRODUCTION

The Archie Creek Fire was identified on September 8, 2020 east of Glide, Oregon along Highway 138 near Steamboat Springs. The fire merged with the Star Mountain Fire in the Susan Creek area on September 10, 2020. Approximately 64,622 acres of private property have been impacted by this fire. The Erosion Treat Assessment/Reduction Team (ETART) identified post-fire risks to property and infrastructure and developed recommendations for the mitigation of impacts to private property and municipal infrastructure.

#### 5.1.2. OBJECTIVES

The purpose of this report is to identify post-fire risks to non-federal public and private properties and infrastructure within the area impacted by the Archie Creek Fire and to develop recommendations for the mitigation of impacts. Specifically, the purpose of the report is to:

- Assess impacts of watershed changes caused by the fires on critical values within non-federal lands focusing on those that pose substantial threats to human life and property, and critical natural and cultural resources. This assessment addresses changes to hydrologic function and watershed response to precipitation events.
- Identify hazards due to potential flooding and identify areas at risk for deposition of debris and sediment.

- Identify potential threats to life, property, and critical natural and cultural resources from flooding and/or deposition of sediment and debris.
- Develop treatment recommendations.
- Identify the need for future monitoring.

## 5.2. Critical Values

Critical values assessed for this report include property, structures, physical improvements, natural and cultural resources, community infrastructure, life and safety. The following discussion is specifically concerned with values on private, municipal, county, and state lands that are at elevated risk of damage from post-fire erosion, flooding, and debris flows within and downstream of the Archie Creek fire. Note that critical values on lands owned by private timber companies e.g. Weyerhaeuser, were excluded from this assessment at the request of the companies. Critical values associated with state and county highways also were generally excluded from the assessment unless specifically requested or the team noticed that the roadway had a stream crossing that could be impacted by flooding or debris. Values on NFS lands are discussed in the Hydrology Resource Assessment prepared as part of the Archie Creek Burned Area Emergency Response (BAER) Report (Sommer, 2020).

## 5.3. Resource Condition and Setting

The Archie Creek Fire was identified on September 8, 2020 east of Glide, Oregon along Highway 138 near Steamboat Springs. The fire merged with the Star Mountain Fire in the Susan Creek area on September 10, 2020. Approximately 64,622 acres of private property have been impacted by this fire. Areas impacted by the fire include the North Umpqua Ranger District of the Umpqua National Forest, the Roseburg District of the Bureau of Land Management, private timber lands, and the communities of Rock Creek and Steamboat along both sides of the North Umpqua River and the Rogue-Umpqua Scenic Highway. Fuel types consist primarily of mixed conifers and shrubs. The forests in the area consist of old growth timber, second-growth stands, and recently harvested lands.

The Archie Creek Fire was significantly different from recent fires within the North Umpqua drainage in that large parts of the fire burned at moderate to high severities. This resulted in wide-spread concern for values at risk, such as life/safety, ESA listed fish habitat, recreation sites, and roads.

The fire impacted 21 miles of the North Umpqua River within the area designated as a National Wild and Scenic River from Rock Creek to Apple Creek Campground. The fire also impacted 45.5 miles of fish-bearing habitat including 16.7 miles of Designated Critical Habitat for Oregon Coast Coho and 18.3 miles of suitable occupied habitat for Coho. The North Umpqua and its tributaries are listed on Oregon DEQ’s 303(d) list of impaired streams for water temperature.

The burned perimeter of the fire included 465.9 miles of streams (170.6 miles perennial and 295.34 intermittent). The fire perimeter included 17 subwatersheds. The heaviest impacted subwatersheds were Lower Rock Creek (59.4% high burn severity) followed by East Fork of Rock Creek (34.9%), and Susan Creek North Umpqua (34.9%). (Figure 1).

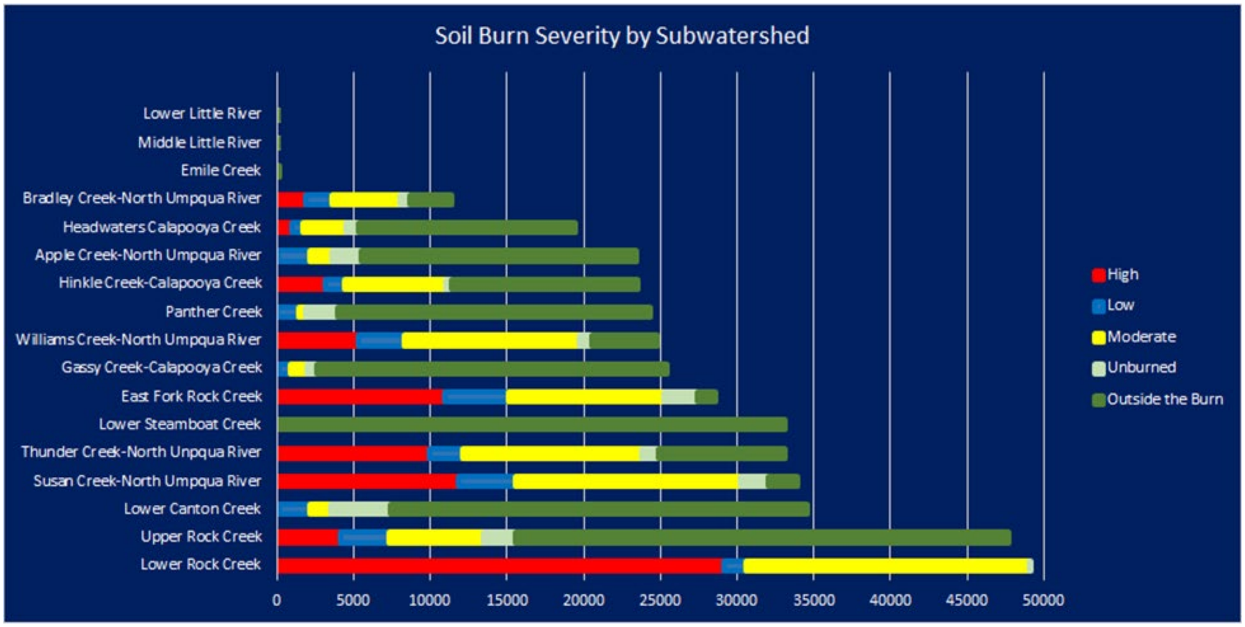


**Figure 1: Soil Burn Severity by Subwatershed**

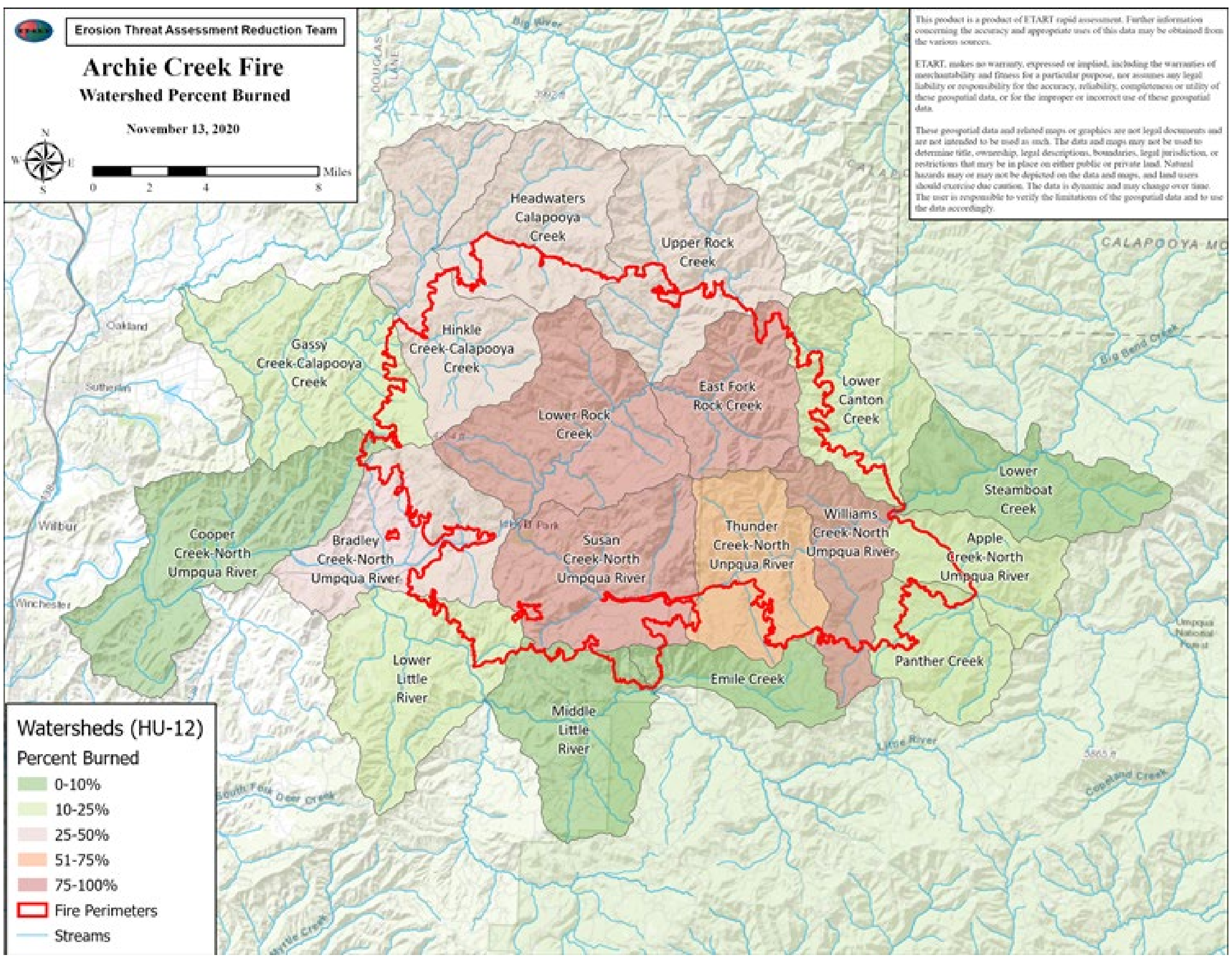


**Figure 2: Map of Archie Creek subwatersheds and percent burned**

### 5.3.1. GEOLOGY

The area impacted by the fire  is characterized by steep side slopes consisting of “V-shaped” canyon walls, some weakly-dissected gentle to moderate side slopes, large areas of dormant landslide-earthflow complexes, and the alluvial valley floor where most private and public resources are located due to proximity to water and flat topography. Soils within the fire perimeter are characterized by fine-textured, poorly-draining soils and highly weathered bedrock materials which allows for minimal water-holding (retention) capacity.  During intense storms (rain on-snow events), surface runoff is rapid, causing flashy flows.  In these steep mountain slopes, rapidly moving, shallow-seated landslides; such as debris avalanches, debris slides, and debris flows are the dominant form of mass-wasting. (Swanson 1987).  Steep slope streams have high-energy gradients that transport cobbles, boulders and large woody debris into higher order systems.

### 5.3.2. CLIMATE

The fire took place in a region that experiences precipitation patterns of frontal rain/snowstorms and occasional summer convective thunderstorms. Precipitation in the area primarily occurs between October and April as multiple day frontal storms. The upper regions of the burned area are within the transient snow zone (2000-5000 feet elevation). The North Umpqua River gorge and its tributary valleys are below 2000’ and within the rain zone.  Late winter rain-on-snow events can result in extreme flood events.  Peak flows can be much higher in the lower tributaries where rainfall and rain-on-snow events are not moderated by the storage capacity of the underlying bedrock, as is the case with streams in the High Cascades geology within the transient snow zone.

La Niña conditions are present in the tropical Pacific, with an approximately 85% chance of lasting through the winter. Forecasters currently project that the 2020-2021 La Niña will be on the stronger side and peak in November–January, which is expected to result in higher precipitation and snowpack. NOAA modeling illustrates that increased runoff is more likely during La Niña years.

## 5.4. Risk Assessment

Fire can cause water-repellant (hydrophobic) soil conditions which decreases infiltration and can lead to amplified surface runoff, erosion, channel scour and instability, and sediment transport and deposition. Anticipated post-fire hydrologic effects from this fire include significantly increased runoff and peak flows resulting in flooding, debris flows, and landslides. Hillslope erosion will also be significant and is discussed further in the soils report. Anticipated downstream effects include significantly elevated peak flows in tributaries and small catchments, periods of very high turbidity affecting drinking water treatment, and warmer summer water temperatures within the fish bearing and perennial tributary streams.

Increased annual peak flows and runoff velocities will result in changes to channel morphology including rill and gully erosion, debris flows in steep headwater basins, scour and incision in low order channels and deposition in higher order streams. These responses are expected to be greatest during large storm events for the next several years and will remain chronic but less evident as vegetation reestablishes. There are 5 United States Geological Survey (USGS) gauges within the fire perimeter (Appendix C, USGS Press Release Sept 23, 2020). These gauges are low in the watershed and may provide limited information within smaller subwatersheds. However, information from these gauges may be important to inform downstream municipal systems.

Stream temperature increases are expected to affect most perennial streams within areas of high tree mortality and will persist until effective shade is restored. Elevated stream temperatures are detrimental to some aquatic species including ESA listed Coho and other salmonids. Changes in water chemistry can also be anticipated post-fire due to increases in nutrients carried to water courses from burned areas. Increases in various forms of nitrogen, phosphorous, and several cations are often observed in the first few storms following fire (NWCG 2001). These nutrients are not hazardous to humans but can result in cyanobacteria blooms and eutrophication in downstream waters. Water quality normally returns to pre-burn levels within 1-2 years following fire (NWCG 2001).

The USGS-Geologic Hazards Division has developed a preliminary hazard assessment of the Archie Creek Fire (see References). This assessment showed a high increase in the probability of debris flow on the southern part of the fire. This increased probability included the Idleyld Park area where a belt of identified landslides is located in a NW to NE trend. (DOGAMI-SLIDO map).

## 5.5. Assessment Methodology – Field and Modeling

Team members surveyed a list of private and publicly owned properties provided by Douglas County, the cities of Glide and Oakland, USACE and other concerned parties. Additional sites were added as additional information became available during the field survey. Sites were assessed based upon visible indicators and best professional judgement to identify the potential risks. These indicators included:

- Steepness of adjacent slopes
- Channel form (e.g., incised canyons) to assess potential flood heights
- Visual confirmation of burn severity
- Size of the subwatershed
- Level of moss on rocks and vegetation type and elevation to indicate flood return intervals of e.g., less than 5 years
- Proximity of identified hazards to private and public infrastructure

Post-fire watershed response for the Archie Creek Fire was conducted in order to determine the impact of SBS on the response of modeled peak flows in drainages with values identified to be at elevated risk. The findings contribute towards understanding post-fire impacts on flooding and subsequent increases in sediment yield and debris flows to evaluate risk to downstream values on state- and county-owned properties and values. Pourpoint watersheds were created to estimate watershed characteristics, analyze drainages, and assess the need for treatment actions.

## 5.6. Findings

The team found numerous values that had varying degrees and types of threats, which are detailed in the Values at Risk table in Appendix G. There are some imminent threats due to existence of numerous hazard trees and large wood that will be entering stream systems. However, flooding at most of these sites is not too likely since they are mostly situated either well above flood stage or downstream of a flood-regulating dam.

Regional regression equations were used to estimate pre- and post-fire peak flows (see Appendix G for further details). Relative increase in 5-year post-fire peak flows is expected to be largest in the North Fork Molalla River where approximately 43% of the watershed has burned. The North Fork Molalla River above Molalla River has a predicted increase in peak flow from 5,553 cfs to 6,917 cfs at the 5-year recurrence interval, an increase of 1.2 times the pre-fire peak flow magnitude. The slightly elevated peak flow response is due to the large portion burned acreage classified as moderate or high soil burn severity in a relatively smaller watershed. In contrast, the increase in magnitude of post-fire peak flows in the other poursheds is 1.1 times the pre-fire peak flow for the 5-year recurrence interval.

This analysis of post-fire peak flows should only be used as a tool to better understand relative stream response levels for various drainages throughout the fire area. Post-fire stream response in smaller watersheds tends to be much greater than those in large watersheds. This is because of the relative volume of water it takes to show an amplified increase from pre-fire flow and the spatial scale of continuous high-severity fire patches in relation to the extent of a storm event in the Cascades.

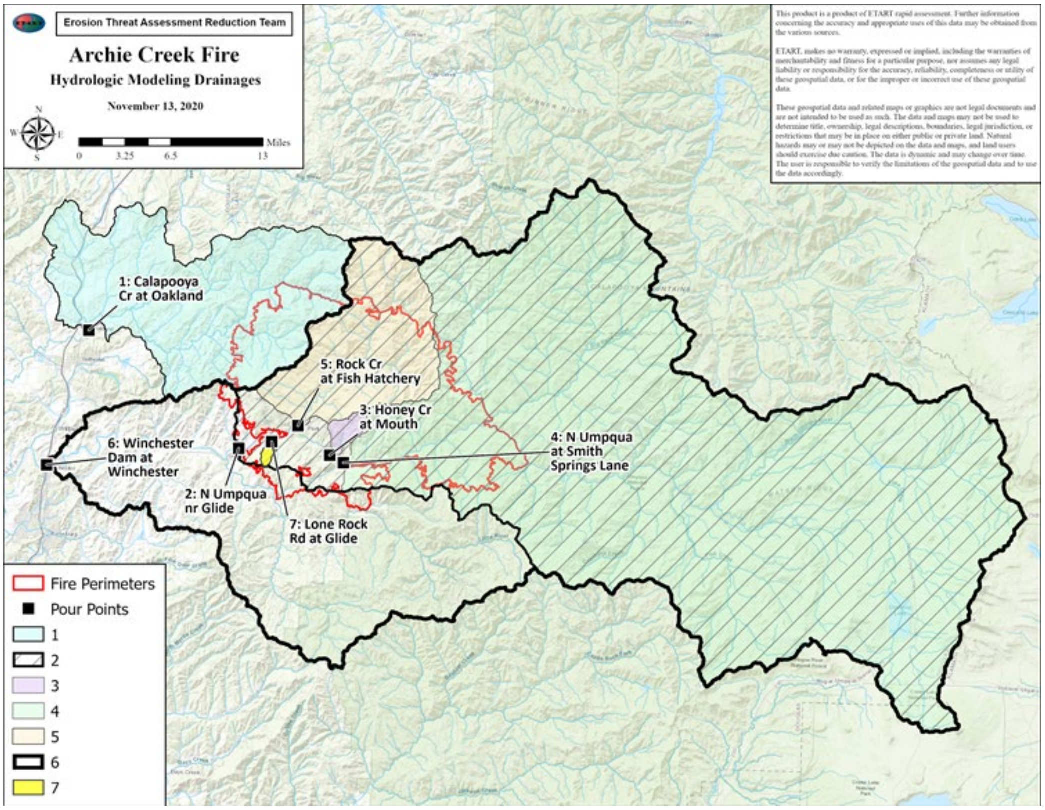


Figure 3: Pourpoint watersheds - Archie Creek Fire

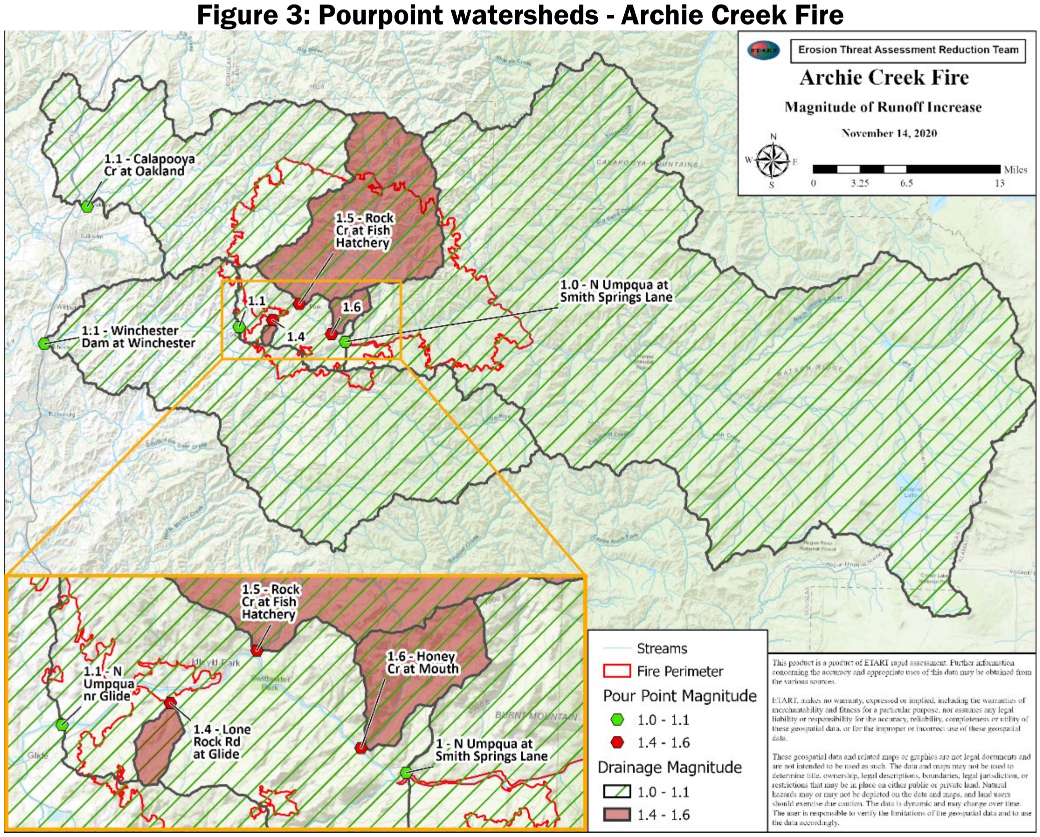


Figure 4: Fire areas and streamflow response for select poursheds – Archie Creek Fire

### 5.6.1. RISK ASSESSMENT

The Impacted properties and infrastructure were identified on the North Umpqua River, Calapooya Creek, Honey Creek, and Rock Creek. Additional areas of concern were identified along unnamed drainages on Bar L Ranch Rd, Lone Pine Rd and Evergreen Rd (Hogback Creek). The anticipated post-fire impacts are increases in peak flows, increased sediment inputs, and increases in large woody debris inputs. The full VAR table for the Archie Creek Fire is contained in Appendix C.

### 5.6.2. MODELING

Post-fire rainfall-runoff characteristics can be strongly influenced by soil burn severity (SBS) which creates a water repellant or hydrophobic layer of soil. Regional regression equations were used to estimate pre- and post-fire peak flows for several watersheds (see appendix C). The relative increase in 5-year peak flows is expected to be largest in watersheds such as Honey Creek and Rock Creek, where 85 to 100% of the watershed was moderately to severely burned (Table 1, Fig. 3, Fig. 4).

The analysis of post-fire peak flows should only be used as a tool to better understand relative stream response levels for various drainages throughout the fire area. Post-fire stream response in smaller watersheds tends to be much greater than those in large watersheds because of the relative volume of water it takes to show an amplified increase from pre-fire flow and the spatial scale of continuous high-severity fire patches in relation to the extent of a storm event in the Cascades.

### 5.6.3. WATER QUALITY

Two municipal water systems were identified within the impact area in the cities of Oakland and Glide. Modeling identified minor peak flow increases for 2-yr and 5-yr flows in the North Umpqua and Calapooya Creek indicating that the post-fire flood risk to these facilities is unlikely to be elevated.

The Rock Creek Fish Hatchery sources water directly from Rock Creek and pumps water from the North Umpqua during the summer months.  Modeled post-fire hydrology of Rock Creek showed a greater than 50% increase in peak flows for the 2-yr and 5-yr event.

Post-fire increases in turbidity, sedimentation, and debris flow. may have adverse impacts on these systems. Continued communication and coordination with partners and downstream users related to water quality is considered essential for relaying the ETART assessment findings, particularly to municipal water supply providers.

**Table 1: Modeling results for post-fire increase in watershed peak flows.**

| | | | Pre-fire | | | Post-fire | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Name** | **Drainage Area** | **% High Burn Severity** | **2-year Peak Flow (cfs)** | **5-year Peak Flow (cfs)** | **10-year Peak Flow (cfs)** | **2-year Peak Flow (cfs)** | **5-year Peak Flow (cfs)** | **2-year Peak Flow increase** | **5-year Peak Flow increase** |
| Calapooya Creek at Oakland | 119,537 | 3.5 | 9,160 | 14,000 | 17,300 | 10,133 | 15,094 | 1.1 | 1.1 |
| Honey Creek at Mouth | 3,301 | 65.4 | 387 | 561 | 677 | 655 | 888 | 1.7 | 1.6 |
| N Umpqua at Smith Springs Drive | 555,779 | 1.9 | 23,700 | 36,200 | 45,500 | 24,767 | 37,527 | 1.0 | 1.0 |
| N Umpqua near Glide | 643,109 | 6.0 | 27,400 | 41,800 | 52,600 | 30,625 | 45,992 | 1.1 | 1.1 |
| Rock Creek at Fish Hatchery | 62,768 | 35.3 | 6,330 | 10,100 | 12,900 | 10,345 | 15,255 | 1.6 | 1.5 |
| Winchester Dam at Winchester | 832,062 | 4.7 | 43,600 | 64,300 | 79,200 | 46,895 | 72,580 | 1.1 | 1.1 |
| Lone Rock Rd at Glide | 714 | 25.4 | 88 | 126 | 152 | 137 | 179 | 1.6 | 1.4 |

### 5.6.4. LIFE AND SAFETY CONCERNS FROM FLOODING AND DEBRIS

High tree mortality poses an immediate risk to life and safety for staff and visitors to the Rock Creek Hatchery and the Rock-ED education center. High burn severity within the Rock Creek and Honey Creek drainages place properties within these areas at high risk for increased flooding and debris flow.

The community of Idleyld Park is at high risk of increased debris flow due to high burn severity within the watershed and the presence of mapped landslides in this area.

The Winchester Dam is located approximately 27 miles from the fire perimeter. However, the Oregon Water Resources Dam Inventory has identified the Winchester Dam as a High Hazard dam and will therefore update the Winchester Dam Emergency Action Plan to account for impacts from the Archie Creek Fire.

### 5.6.5. PROPERTY RELATED CONCERNS FROM FLOODING AND DEBRIS

Properties and infrastructure within Honey Creek and Rock Creek were identified to be at high risk to damage due to high tree mortality and localized post-fire soil erosion, landslides and increases to peak flows. Honey Creek and Rock Creek showed a greater than 50% increase in peak flows for the 2-yr and 5-yr event.

One property was identified at high risk on Honey Creek Rd. The homesite is located in a steep canyon within the floodplain of Honey Creek. The steep slopes above the homesite have been severely burned and there is no remaining understory. Soil slumping may cause immediate danger to the property and slumpage may block Honey Creek, pushing water onto the floodplain. Modeling of post-fire peak flows showed a greater than 50% increase in peak flows for the 2-yr and 5-yr event. This increased runoff within the watershed is expected to increase flooding.

## 5.7. Recommendations

The Archie Creek Fire was characterized by higher burn severity than that which had been observed in recent fires within the watershed. Outreach and education to the affected population is recommended. Education should focus on immediate hazards such as the presence of hazard trees and the potential for increased flooding and landslides in the coming winter. Signage identifying potential hazards is recommended in heavily used areas. A list of resources such as the *Preparing for Landslide Hazards: A Land Use Guide for Oregon Communities (2019)* should be made available.

The property on Honey Creek is at high risk for post-fire hydrological impacts. Additionally, this property is under elevated risk because there is no secondary access to the site. Due to the high post-fire hazards identified, investigation of a property acquisition program is recommended.

### 5.7.1. RECOMMENDED MONITORING

#### Life and Safety

The ETART hydrology team identified several areas of potential concern for life and safety. The safest treatment is to restrict access to areas with high risk for flooding, landslides, and debris flows by use of physical closures and signs.

The use of storm patrol following large rain events and following snowmelt runoff would inform future decisions about the need to re-assess hazards to life and safety over time as natural recovery takes place.

Further assessment of undersized culverts on public roads is recommended to identify risks to life and safety and/or property from increased post-fire runoff and potential debris-laden flows, as well as appropriate treatments such as upsizing culverts or removing structures where appropriate.

Although not an ETART treatment, further evaluation of the potential risk of flood impacts, shallow landslides and debris flows for rain-on-snow events through additional flood and shallow landslide modeling is recommended. A better understanding of flood risk may inform longer-term disposition of road crossings, ODOT Hwy 138, and public and private structures within or downstream of the fire area. Continued coordination between the NWS, NRCS, Douglas County, USACE, USGS, DOGAMI, ODOT, and other concerned entities is also recommended.

#### Hydrologic Function

Natural recovery is recommended as the most effective and low-cost treatment to post-fire impacts to hydrologic function.

Baseline post-fire water quality conditions should be established at the Rock Creek Hatchery prior to the winter rains. Post-event sampling for all environmental monitoring constituents should be conducted (Hatchery Management Plan, 2020). Instream temperature monitoring is also recommended.

## 5.8. References

Hydrology and Watershed Specialist Report. Archie Creek Fire. Burned Areas Emergency Response (BAER). Umpqua National Forest. October, 2020

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# 6. Geologic Hazards

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## 6.1. Introduction

This report is a rapid post-wildfire geologic hazards assessment of the non-federal land portions of the Archie Creek Fire area. Hazards assessed include debris flows, rockfall, shallow and deep landslides and related flash flooding/hyper-concentrated flow that may adversely impact public safety and (or) infrastructure.

Wildfire can significantly change the hydrologic response of a watershed to the extent that even modest rainstorms can produce dangerous flash flooding and (or) debris flows. Areas downstream of slopes burned by wildfire were assessed for historic evidence of debris flow impacts through limited field reconnaissance and GIS interpretation. This is a qualitative assessment based on our professional judgement and experience and was performed in cooperation with U.S. Forest Service (USFS), U.S. Geological Survey (USGS), and the State of Oregon Department of Geology and Mineral Industries (DOGAMI). Summarized in the report are geologic observations, interpretations, and recommendations.

The Archie Creek Fire was detected on September 8, 2020 at approximately 7:30 a.m. in the Steamboat Springs area along Highway 138, east of Glide, Oregon. On September 10th, 2020, it merged with the Star Mountain Fire in the Susan Creek area. The fire burned on the North Umpqua Ranger District of the Umpqua National Forest, the Roseburg District of Bureau of Land Management, private timber land, and through the communities of Rock Creek and Steamboat along both sides of the North Umpqua River and the Rogue Umpqua Scenic Highway. The fire is currently 131,542 acres and 95% contained (as of 10/22/2020). Approximately 64,622 acres were private property, including private timber land and residences. Forest Service lands accounted for 26,490 acres, and BLM accounted for 40,391 acres.

The USFS assembled a Burned Area Emergency Response (BAER) team on September 26, 2020. The BAER team of experts in soils, geology, hydrology, engineering, botany, recreation, archaeology, wildlife, fisheries, and GIS began assessing the post-fire effects to assets/critical values on USFS managed lands. The team developed a Soil Burn Severity (SBS) map to document the degree to which soil properties had changed within the burned area. Fire damaged soils have low strength, high root mortality, and increased rates of water runoff and erosion. Using the SBS map, BAER team members ran models to estimate changes in stream flows (hydrology) and the USGS ran models for debris flow (soils and geology) potential. Even though the reports produced by this team cover the USFS land only, the reports are likely generally applicable for communities just outside the forest boundary and we recommend these reports are acquired and consulted.

On October 26, 2020, the Oregon Erosion Threat Assessment and Reduction Team (ETART) was formed to make assessments of state, county, and private lands and property using information collected by the BAER team. The ETART team of experts from a variety of national, state, and local agencies in soils, geology, hydrology, engineering, botany, recreation, archaeology, wildlife, fisheries, and GIS began assessing the post-fire effects to assets/critical values on non-federal lands managed lands.

### 6.1.1. RAPID ASSESSMENT OBJECTIVES

When evaluating geologic hazards, the objectives of the “Geology” specialty group on an ETART Team are to identify the geologic conditions and geomorphic processes that have helped shape and alter the watersheds and landscapes and assess the impacts from the fire on those conditions and processes that could affect downstream assets/critical values. The fire removed vegetation which keeps slopes and drainages intact, changed the structure and erosiveness of the soil, and altered the stability of the landscape. Using the understanding of rock types and characteristics, geomorphic processes, and distribution of geologic hazards helps predict how the watersheds will respond to and be affected by upcoming precipitation events. Analysis focused on areas where geologic hazards coincide with assets/critical values. In addition to the immediate threats, considerations also include geologic hazards that are more likely to occur during the coming years and up to 15 years post-fire. The following tasks were performed:

- Review mapping products to generate a risk map within the fire areas.
- Limited on the ground reconnaissance of burned area
- Development of this report that describes the risks of geologic hazards across the fire and identifies assets/critical values at high risk.
- Emergency response recommendations
- Additional analysis and advice, as requested, for the fire assessment teams for specific assets/critical values that are of high concern for post-fire effects.

### 6.1.2. GEOLOGIC HAZARDS DESCRIBED

The fire is located within the Cascade Mountains geologic province.  The Cascade Range is almost entirely comprised of igneous extrusive volcanic rocks and are the magmatic expression of the Cascadia subduction zone where the Juan de Fuca tectonic plate is being subducted beneath the North American plate. The Cascade Range is divided into two physiographic sub provinces: Western Cascades and the High Cascades.

Landslides are one of the most widespread and damaging natural hazards in Oregon. The general term “landslide” refers to a range of mass movements including rockfall, debris flows, and earth slides. Different types of landslides have varying frequencies of movements, triggering conditions, and very diverse resulting hazards. In the Cascades, debris flows and related flash flood/hyper concentrated flow events, rockfall, shallow and deep landslides are the most common types of landslides.

Debris flows are a complicated landslide process. They commonly start or initiate on steep slopes or colluvium-filled hollows or in a drainage in the upper portions of a basin. As the landslide moves down the channel, they commonly grow in volume through erosion of the sediments and debris on the channel bed, erosion of the channel banks, rilling and surface erosion of slopes adjacent to a channel, or by coalescing with adjacent channel debris flows, and the addition of water. As they continue to transport down the channel, depending on volume and channel gradient debris flow can reach speeds of 100 miles per hour. The downslope transport distance can be relatively long depending on the morphology of the channel. For example, some have traveled over a mile down a channel before they stop. When the debris flows reach the canyon mouth, the debris spreads out over the flatter unconfined ground (generally referred to as run out), many times forming a fan shaped deposit frequently made up of many events. Life safety is the biggest concern because debris flows can start a long distance away from final depositional zones and thus residents can be unaware of the pending danger. Vegetation and soil changes after a fire increase the runoff and erosion in a watershed and can significantly increase the likelihood of debris flows and flash flooding. Flash flooding and debris flows can initiate during even moderate rainstorms over burn areas and often occur with very little warning. Post-fire flow can alternate between flood and debris flow depending on the concentration of sediment and debris in transport.

In addition to debris flows, rockfall and post-fire activation/reactivation of shallow and deep landslides can occur. Rockfall is common throughout the Cascades where steep/near vertical cliffs form. Shallow landslides are also very common throughout the Cascades especially on relatively steep soil/colluvium mantled slopes. The influence of root reinforcement on shallow landslides has been widely established. Beginning in less than five years after a fire, when roots of burned trees lose strength, heavy rains could saturate and destabilize steep slopes and cause them to slide.

## 6.2. Assessment Methodology

Assessment of potential post-fire impacts from geologic hazards at locations intersecting infrastructure and public safety were reliant upon limited observations in the field, LIDAR derived topography (where available), soil burn severity maps (SBS), GIS data with buildings/structures and infrastructure, USGS emergency assessments of post-fire debris-flow hazards, Statewide Landslide Information Database of Oregon (SLIDO), and orthoimagery. A detailed list of assessments is included in the Appendix D of this report.

The USGS emergency assessments of post-fire debris-flow hazards is considered ongoing research and 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 (Staley, 2013). They recommend using the hazard data with a 15-minute rainfall intensity of 24 millimeters (~1 inch) per hour (mm/h) and is included in Appendix D, Figure 1.

The USGS Landslide Hazards Program, in cooperation with DOGAMI and university researchers, are actively conducting research to better calibrate the model to western Oregon. At this time the model may overestimate or underestimate the risk in some areas. Model thresholds can provide approx. information for warning systems but should be considered alongside hydrologic modeling and local knowledge.

SLIDO is a compilation of existing landslide deposits and landslides susceptibility in Oregon that have been compiled from published maps. Many landslides have not yet been located or are not on these maps and therefore are not in this database. The original studies vary widely in scale, scope, and focus, which is reflected in a wide range in the accuracy, detail, and completeness with which the landslides are mapped.

In addition to the immediate threats, considerations also include shallow-landslide-initiated debris flows that are more likely to occur roughly 3-15 years post-fire and are unlikely to be an immediate post-fire concern.

Reconnaissance of the burn area was a rapid assessment at high level. The assessment concentrated on local communities at risk, state and county property, transmission lines, dams and reservoirs, schools, non-profit education and sport camps, and fish hatcheries.

## 6.3. Findings

The following is a summary of the observations and interpretations. A detailed list is included Appendix D to this report. Below is a short list of the primary high-risk assets/critical values:

**Community of Idleyld Park** – Portions Idleyld Park are built on deep landslide deposits that could reactivate post fire. Portions of these communities are located very close to and below channels identified by the USGS as moderate and high potential for debris flows. Furthermore, portions of these communities are built on debris flow fan deposits, which is the runout/deposition zone for any potential debris flow from channels above. (Appendix A, Figure 2)

**Rock Creek Hatchery and Rock-Ed Education Center** – The fish hatchery and education center are built on deep active landslide deposits that could further reactivate post fire. Increased rockfall hazards exist near the steep slopes. The portions of hatchery and education center are in the runout/deposition zone potential debris flow hazards from channels above. These channels were identified by the USGS as moderate and high potential for debris flows hazards. (Appendix A, Figure 3, Photo 1 & 2)

**Honey Creek-Dogwood Motel** – Dogwood Motel and community along OR 138 at Honey Creek are built on deep landslide deposits that could reactivate post fire. Portions of these communities are located very close to and below channels identified by the USGS as moderate potential for debris flows. Furthermore, portions of this community and the motel are built on debris flow fan deposits, which is the runout/deposition zone for any potential debris flow from channels above. (Appendix A, Figure 4)

**Oregon State Route 138** – The state highway was not specifically analyzed by this report. Dependent on the specific location along the highway, a variety of post-fire geologic hazards are likely including, flooding, erosion, sluffing, dry ravel, rockfall and debris flows. Communications with ODOT geologist and geotechnical engineers indicate that they are currently planning and addressing rockfall and potential debris flow hazards to the highway corridor. (Appendix A, Figure 1, 2, 3, & 4)

During the ground survey, evidence of widespread mass wasting, rockfall, landslides, and debris flow deposits were observed throughout the burned area. People living, working, traveling or recreating through and below burned areas could be subject to loss of life or injury as a result of debris flows, rockfall, or flash flooding in and downstream of the burn area. For further site-specific areas such as State and county roads, private access roads, and water systems refer to the ETART hydrologic and engineering reports for recommendations of operation and maintenance of those facilities. For critical infrastructure, such as transmission lines and pipelines, examine the provided maps, data, and models to determine if further site-specific evaluation is needed.

Depending on the specific location of these assets/critical values, some of these might be impacted by various types of slope failures such as landslides and/or rockfall, while others might be impacted by hyper-concentrated flows and/or debris flows. In addition to the immediate threats, longer term landslide hazards are more likely to occur during the next several years to 15 years.

Based on this rapid assessment, we find there is a range of landslide risk highly dependent on location from very low to high within the fire affect area. Therefore, we make the following recommendations to reduce landslide risk. These recommendations are focused on life safety.

## 6.4. Recommendations

This rapid assessment was performed to alert communities in portions of Archie Creek Fire of the need to be prepared for post-fire landslides. We note that the portion of Oregon included in this assessment has high average annual precipitation as well as potentially high 24-hour-duration precipitation related to storm events. Both factors are extremely important in triggering landslides, especially when combined with the local geology and geomorphology. Human activities may also contribute and/or trigger landslides.

The results of this rapid assessment indicate that some assets/critical values in the Archie Creek Fire area are at high risk from post-fire landslide hazards. Post-fire debris flows are generally the primary concern because of their speed, debris flows threaten both lives and property. Rockfall is also a primary concern. Shallow and deep landslides cover a much broader area and can threaten property and possibly lives in the long term.

We provide the following recommendations to communities in the fire area for continued work on landslide risk reduction. These recommendations are not comprehensive, but they should provide an adequate foundation. The primary actions are awareness, warnings, and emergency mitigation/further evaluation. Additional details are provided below.

### 6.4.1. AWARENESS

Awareness of local hazards is crucial to understanding associated dangers and how to prepare for them. One of the main purposes of this assessment and data compilation is to help residents and landowners in the fire area become aware of the risk reduction actions they can take for preparation for hazardous events.

At many sites, we recommend signs are placed in locations to help awareness and remind everyone of the potential risk. These signs should include a clear message and a link to additional information (Appendix D).

To increase awareness, the following flyers and fact sheets can be linked and and/or distributed to help educate landowners of activities that individuals can take in order to reduce landslide risk.

| Educational Flyers |
| --- |
| Homeowners Guide to Landslides<br>▪ https://www.oregongeology.org/Landslide/ger_homeowners_guide_landslides.pdf<br>Landslide Hazards in Oregon |

- https://www.oregongeology.org/pubs/fs/landslide-factsheet.pdf

Debris flow hazards. Includes recommendations for before and during events

- https://pubs.usgs.gov/fs/fs-176-97/fs-176-97.pdf

Post Wildfire Flash Flood and Debris Flow Guide

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

General landslide preparedness

- https://www.usgs.gov/natural-hazards/landslide-hazards/science/landslide-preparedness?qt-science_center_objects=0#qt-science_center_objects

State, city, county, and other local community leaders can implement awareness campaigns to educate neighborhoods, businesses, and individual homeowners about the locations of local hazards and how to reduce risk. For example, just knowing if one lives in a debris flow susceptible area can provide the impetus to switch to actively reducing risk through monitoring and preparing for evacuation if necessary.

### 6.4.2. LANDSLIDE WARNINGS

Preparing for emergency situations such as storm events can be done in several ways. Oregon has a statewide landslide alert system triggered by the National Weather Service (NWS). When the NWS issues a flood watch or flash flood watch, they include language about the potential for landslides and debris flows. Several Oregon state agencies (Oregon Emergency Management [OEM], Oregon Department of Transportation [ODOT], and DOGAMI) then disseminate the alert. The current alert system could be used by the communities in the fire area. In addition, the USGS Landslide Program has conducted emergency assessments of post-fire debris-flow hazards in the fires that occurred in Oregon during the 2020 season (https://landslides.usgs.gov/hazards/postfire_debrisflow/). The following are the 15, 30, and 60-minute rainfall amounts for post-fire debris flow potential for the five largest fires in the Cascades.

- Archie Creek
  - 15-minute: 19 mm/h, or 0.2 inches in 15 minutes
  - 30-minute: 15 mm/h, or 0.3 inches in 30 minutes
  - 60-minute: 13 mm/h, or 0.5 inches in 60 minutes
- Beachie Creek
  - 15-minute: 24 mm/h, or 0.25 inches in 15 minutes
  - 30-minute: 19 mm/h, or 0.4 inches in 30 minutes
  - 60-minute: 17 mm/h, or 0.65 inches in 60 minutes
- Holiday Farm
  - 15-minute: 22 mm/h, or 0.2 inches in 15 minutes
  - 30-minute: 17 mm/h, or 0.3 inches in 30 minutes
  - 60-minute: 15 mm/h, or 0.6 inches in 60 minutes

- Lionshead
  - 15-minute: 36 mm/h, or 0.35 inches in 15 minutes
  - 30-minute: 28 mm/h, or 0.55 inches in 30 minutes
  - 60-minute: 26 mm/h, or 1.0 inches in 60 minutes
- Riverside
  - 15-minute: 28 mm/h, or 0.3 inches in 15 minutes
  - 30-minute: 22 mm/h, or 0.45 inches in 30 minutes
  - 60-minute: 20 mm/h, or 0.8 inches in 60 minutes

Additionally, after the 1996-97 landslide events, DOGAMI created a map of 24-hour rainfall intensity that is likely to trigger debris flows for western Oregon. Although post-fire affects are not included in the DOGAMI thresholds, it is another resource that should be reviewed before future storms. Below are the lowest rainfall intensities for each fire.

- Archie Creek - 3-4 inches in 24 hours
- Beachie Creek - 4-5 inches in 24 hours
- Holiday Farm - 3-4 inches in 24 hours
- Lionshead - 2-3 inches in 24 hours
- Riverside - 3-4 inches in 24 hours

Knowing when there will be periods of increased landslide potential will help communities prepare and respond should landslides occur. Evacuation should be considered, recommended, or required under certain conditions in high risk areas.

A life-safety action plan also can be enacted. When the NWS issues a flood watch or flash flood watch with landslide and debris flow language, local emergency managers can relay that information to residents located in high debris flow hazard areas. This could entail a local emergency notification system directed by the county or city or a reverse 911 call being put out to residents when a debris flow warning is issued, alerting them to the potential danger.

## 6.5. Mitigation and Further Evaluation

This is a high-level report, done through a rapid assessment of areas prone to geologic hazards. Most properties identified in this report were not fully assessed. A more complete assessment requires examining the on the ground characteristics of each property at risk. Therefore, we recommend additional site-specific evaluation. The results of a site-specific evaluation should include recommendations for site-specific mitigation. Protecting homes from the impacts of large debris flows should be explored but may need additional design resources and consultation with engineers that is outside the scope of this evaluation. In some cases, from this review, the report points to high hazard areas that would need “further evaluation.” Further evaluation could lead to constructing mitigative control structures. Engineered debris flow diverting structures were not evaluated by this report. These structures need to be surveyed and designed for specific areas they would be needed. Examples of debris flow and rockfall structures may include:

Debris flow

- Debris basin
- Deflection wall or berm
- Terminal wall or berm
- Small log crib check dams located near distal end of fan
- Debris racks (straining structure)
- Debris check dams

Rockfall

- Hand/mechanical scaling
- Trim blasting
- Rock bolts
- Anchored wire mesh/draped mesh
- Shotcrete
- Barrier and fences

Other forms of mitigation to consider should include emergency management buyouts of property with very high risk. Consulting an expert to conduct a site-specific evaluation if considering reconstruction or new construction in these high-risk areas. Residents on the fans should consider flood insurance coverage if possible, consult the Post Wildfire Flash Flood and Debris Flow guide https://www.wrh.noaa.gov/lox/hydrology/files/DebrisFlowSurvivalGuide.pdf.

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# 7. Hazard Trees

I. Blakey Lockman- Regional Pathologist, USDA Forest Service, PNW Region, State and Private Forestry

This report is a rapid post-wildfire danger/hazard tree assessment of the non-federal land portions of the Archie Creek Fire.

## 7.1. Objectives

This assessment provides a high-level look at the potential for danger/hazard trees along roads and around structures in the non-federal portions of the Archie Creek Fire. It is not meant to be an assessment of each mile of road, nor of each structure, but an overall look at the vegetation burn severity along the roads and around structures that lead to a risk of danger trees. Overall objectives of this assessment are:

- Assess the miles of roads traveling across non-federal lands that are most likely to have danger trees
- Assess the number of structures, and the acres surrounding these structures, that will need detail assessments for danger/hazard trees
- Provide general details on criteria used to assess danger/hazard trees
- Provide information on training available for assessing danger/hazard trees

## 7.2. Danger/Hazard Trees Described

A danger/hazard tree is defined as a tree that is located near a structure, roadway, or infrastructure that has an imminent or immediate risk of failing. Danger/hazard trees pose safety hazards to the public and must be identified for prompt mitigation of the risk.

Trees along open roads and surrounding structures in areas of low to high vegetation burn severity are susceptible to falling and pose an imminent hazard to people and property within striking distance if they fall. Trees that are determined to be a danger and could cause damage to life and property along roads and around private structures should be mitigated by closing roads, preventing access to structures, or felling the trees.

For the purpose of this document the terms danger and hazard trees are synonymous. The USDA-FS PNW region has guiding documents that reference both danger and hazard trees. The Field Guide for Danger Tree Identification and Response along forest Roads and Work Sites in Oregon and Washington (Filip et al. 2016) uses the term danger trees for identifying trees surrounding roads or work sites. The Field Guide for Hazard Tree Identification and Mitigation on Developed Sites in Oregon and Washington Forests (Filip et al. 2014) is a similar guide for developed recreation sites and uses the term hazard trees for identifying trees surrounding sites with permanent infrastructure.

### 7.2.1. ROADS ANALYSIS

- Roads within the Archie Creek Fire were stratified by underlying ownership and percent basal area mortality. Miles per basal area burn severity class were then calculated (Table 1).
- Roads within the fire perimeter were then symbolized by basal area burn severity class and mapped on top of the soil burn severity layer (Figure 1).

**Table 1. Miles of road by basal area mortality on Archie Creek Fire. This provides a coarse estimate of miles of roads where roadside danger tree treatments will be needed. Underlying land ownership is the land under and around the road. Orange shading indicates state, county and non-industrial private land ownership, including unspecified private lands.**

| Miles of Road by basal area mortality (BA Mort) | | | | | | | |
|---|---|---|---|---|---|---|---|
| Fire Name | Underlying Land Ownership | 0.0 | Low BA Mort (1-50%) | Mod BA Mort (51-75%) | High BA Mort (>75%) | Total Miles | Total BA Mort Miles |
| Archie Creek | BLM | 41 | 33 | 29 | 96 | 199 | 158 |
| | Private (Unspecified) | 47 | 42 | 56 | 234 | 379 | 332 |
| | State | 1 | 2 | 3 | 2 | 8 | 7 |
| | USFS | 3 | 2 | 0.8 | 3 | 9 | 6 |
| **Archie Creek Total** | | **92** | **80** | **89** | **335** | **596** | **503** |

There are nearly 295 miles of roads with moderate to high levels of basal area mortality on state and private land, with another 45 miles with low basal area mortality (less than 50%; Fig. 1). Cost to mitigate danger trees along these roads will vary with the mortality that occurred due to fire, post-fire mortality that will occur within the next 3 to 5 years, as well as the size of the trees which determines the failure zone. Additional details on determining if a tree is a danger or will become a danger are discussed below in “Damage indicators likely to contribute to failure of fire-injured trees”.

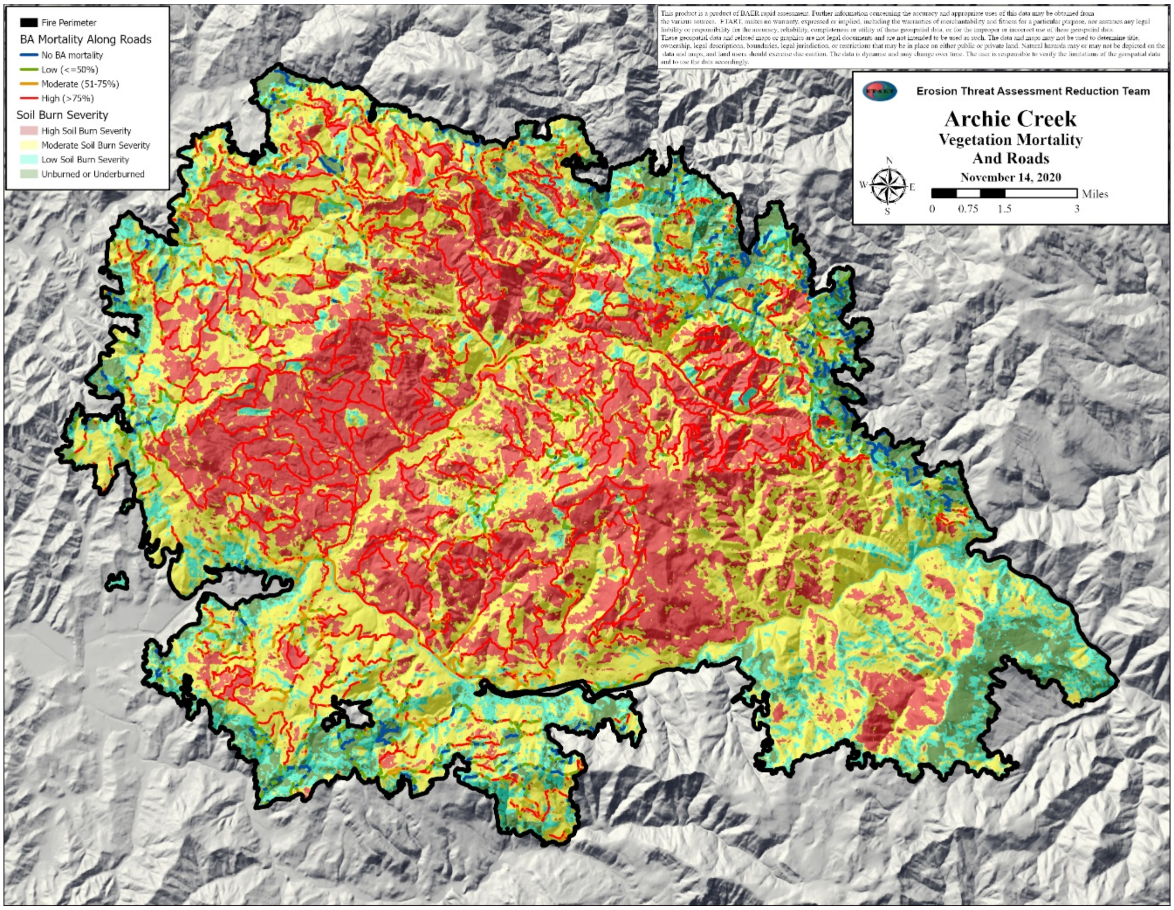


**Figure 1. Roads mapped by percent basal area mortality within the Archie Creek Fire perimeter.**

### 7.2.2. STRUCTURES ANALYSIS

- Acres within a 100’ buffer surrounding all structures within the Archie Creek Fire perimeter were calculated and then stratified by percent basal area mortality class (none, low (1-50%), moderate (51-75%), high (>75%)). One hundred feet was used as a surrogate for the average height of trees assessed for hazard and within striking distance of structures. The numbers of structures were also counted by percent basal area mortality class (Table 2).

- Structures were then symbolized and mapped on top of the basal area burn severity map to provide a visual and to assist with general location of structures (Figure 2).

**Table 2. Numbers of structures and acres by percent basal area mortality within 100-foot buffer surrounding structures in fire perimeter.**

| | None (No BA Mortality) | | Low BA Mort (1-50% BA Mortality) | | Mod BA Mort (51-75% BA Mortality) | | High BA Mort (>75% BA mortality) | | Total BA Mort (>1% BA Mortality) | |
|---|---|---|---|---|---|---|---|---|---|---|
| Fire Name | Acres within 100' foot buffer | Number of structures | Acres within 100' foot buffer | Number of structures | Acres within 100' foot buffer | Number of structures | Acres within 100' foot buffer | Number of structures | Acres within 100' foot buffer | Number of structures |
| Archie Creek | 78 | 85 | 75 | 76 | 71 | 86 | 78 | 85 | 75 | 76 |

There are nearly 180 structures located in areas that suffered 50% or greater basal area mortality (Fig. 2). Another 76 structures are located in areas that suffered less than 50% basal area mortality. A 100-foot buffer was drawn around these structures and the acres calculated by basal area burn severity class to provide some guidance on the level of hazard trees that need to be mitigated. There are over 263 acres of hazard trees within the 100' buffer surrounding all structures. The radius of 100 feet was used as a surrogate for tree height, which determines the failure zone. The actual failure zone around structures may be less with shorter trees and greater with taller trees. Additional details on determining if a tree is a hazard or will become a hazard are discussed below in "Damage indicators likely to contribute to failure of fire-injured trees".

## Work sites around recovery efforts

Many activities involving people and machinery will occur within the fire perimeter during the recovery efforts. Danger trees should be evaluated around these work sites for their likelihood of failure.

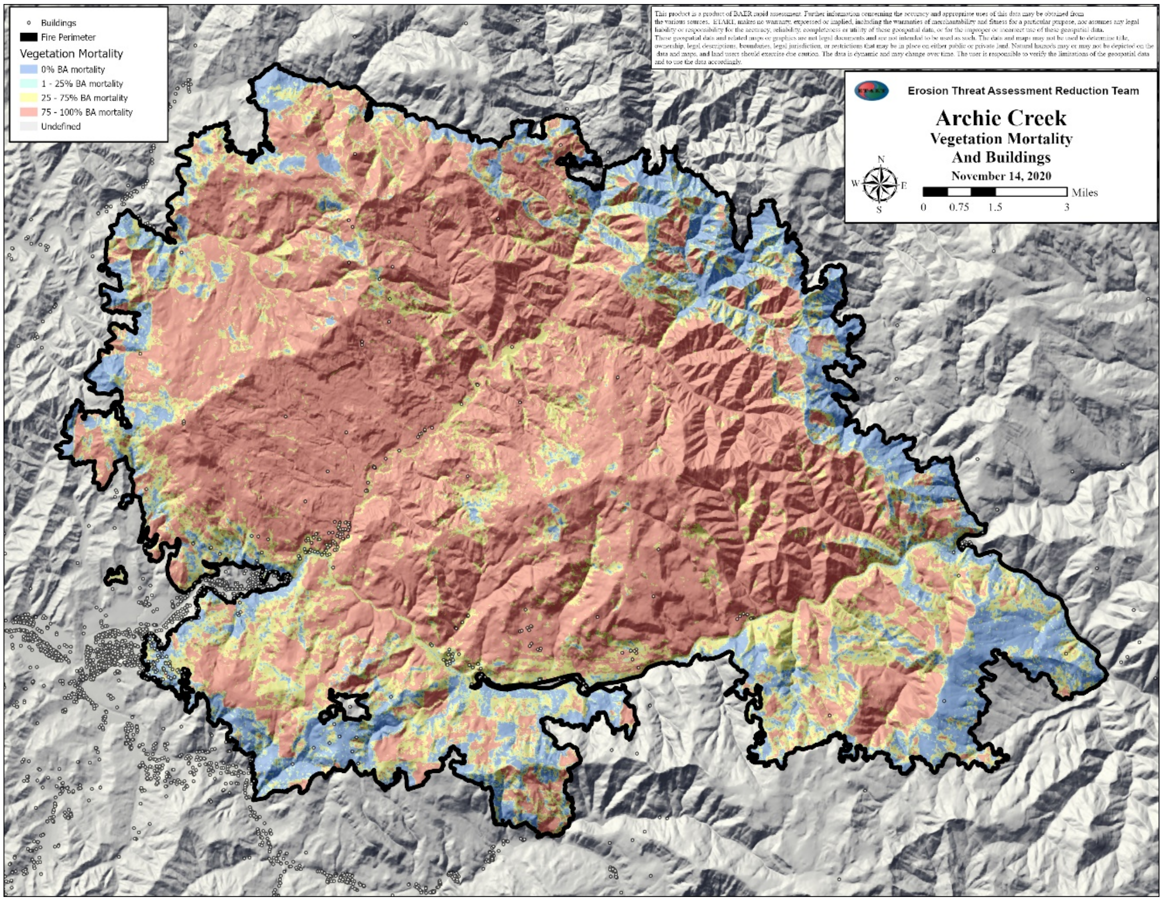


**Figure 2. Location of structures within the Archie Creek Fire perimeter and their locations relative to vegetation mortality.**

## 7.3. Recommendations

- Fell all trees assessed to be a danger and within the potential failure zone of road systems, work sites, and around structures.
- If resources are limited for accomplishing the felling of all danger trees, then:
  - Roads and structures should be prioritized for evaluation and treatment;
  - Close roads until danger trees can be assessed and felled;
  - Prevent access to structures until danger trees can be assessed and felled.

Recommendation is to use the USFS publication, Field Guide for Danger Tree Identification and Response along Forest Roads and Work Sites in Oregon and Washington (Filip et al. 2016) along with Post-fire Assessment of Tree Status and Marking Guidelines for Conifers in Oregon and Washington (Hood et al. 2020) to assess and mark danger trees for removal.

### 7.3.1. MONITORING

It would be prudent to monitor roads and areas surrounding structures for continued mortality and failure for 3-5 years after initial mitigation. Although the provided guidelines and criteria are meant to identify danger/hazard trees, not all trees will be accurately assessed, and further mortality or degradation may occur after initial assessment and mitigation.

**Resources available for assessing danger/hazard trees on the ground**

- OSU Fire Extension has recorded a number of post-fire webinars. Links to these webinars, as well as an extensive summary of resources available, can be found by following this link: https://extension.oregonstate.edu/fire-program.
- ODF post-fire resources, including information on locating stewardship foresters, can be found here: (https://www.oregon.gov/odf/fire/Pages/afterafire.aspx)
- *Field Guide for Danger Tree Identification and Response along Forest Roads and Work Sites in Oregon and Washington.* Link in references and here: http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fseprd512960.pdf
- Post-fire tree mortality assessment and marking guidelines. Link in references and here: https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fseprd814664.pdf
- If on the ground training is needed, this can be arranged by contacting ODF and/or OSU Extension. USFS State and Private Forestry also has experts on staff to help with trainings for assessing trees post-fire at the request of ODF.

### 7.3.2. FURTHER EVALUATION OF DANGER/HAZARD TREES

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#### Damage indicators likely to contribute to failure of fire-injured trees

The following are damage indicators from the USDA-FS Danger Tree criteria (Filip et al. 2016) that should be considered in the post-fire period. Damage thresholds for determining structural stability of a tree are outlined later in this document.

- Trees with **bole cross-section partially consumed**, may be at base or higher on the bole (Filip et al. 2016). This is one of the most common causes of failure post fire.
- Trees with **undermined or severed roots, or roots consumed** by fire (Filip et al. 2016)
- Trees with **cracks or splits** (due to fire and wind) (Filip et al. (2016) refers to this as a bole crack)
- **Detached or broken tops, branches, or bark** (Filip et al. 2016)
- **Recent leaning and/or root sprung trees.** Filip et al. (2016) uses degree of lean greater than 15 degrees.

- Trees with **multiple indicators that are synergistic** where one condition worsens the other. This is very common post-fire where pre-existing conditions are often exacerbated by fire, leading to a tree being a danger. Examples of multiple indicators include: a bole wound with a crack; trees with undermined or severed roots and a lean; stem decay and cracks.
- Additional criteria for determining likelihood of post-fire tree mortality are below.

## Additional Criteria for Determining Danger / Hazard Trees After Wildfire

The determination of danger trees after wildfire is based on two documents:

1. Danger Tree Guidelines document: Field Guide for Danger Tree Identification and Response along forest Roads and Work Sites in Oregon and Washington (Filip et. al. 2016)
2. Post-fire Tree Mortality Guidelines document: Post-fire Assessment of Tree Status and Marking Guidelines for Conifers in Oregon and Washington (Hood et al. 2020)

The two documents work together, as shown in Figure 3, to determine if a tree qualifies as a danger tree. First, dead trees are evaluated for their failure potential using Filip et al. (2016). If the tree is damaged, but alive, then it should be evaluated for structural damage using Filip et al. (2016), and subsequently evaluated using Hood et al. (2020) to determine if the tree will likely die within five years of the wildfire. If the tree is likely to die from the fire, then the Danger Tree Guidelines document (Filip et al. 2016) for recently dead trees is used (even if the tree still has green foliage) to determine if the tree is likely to fail within 5 years.

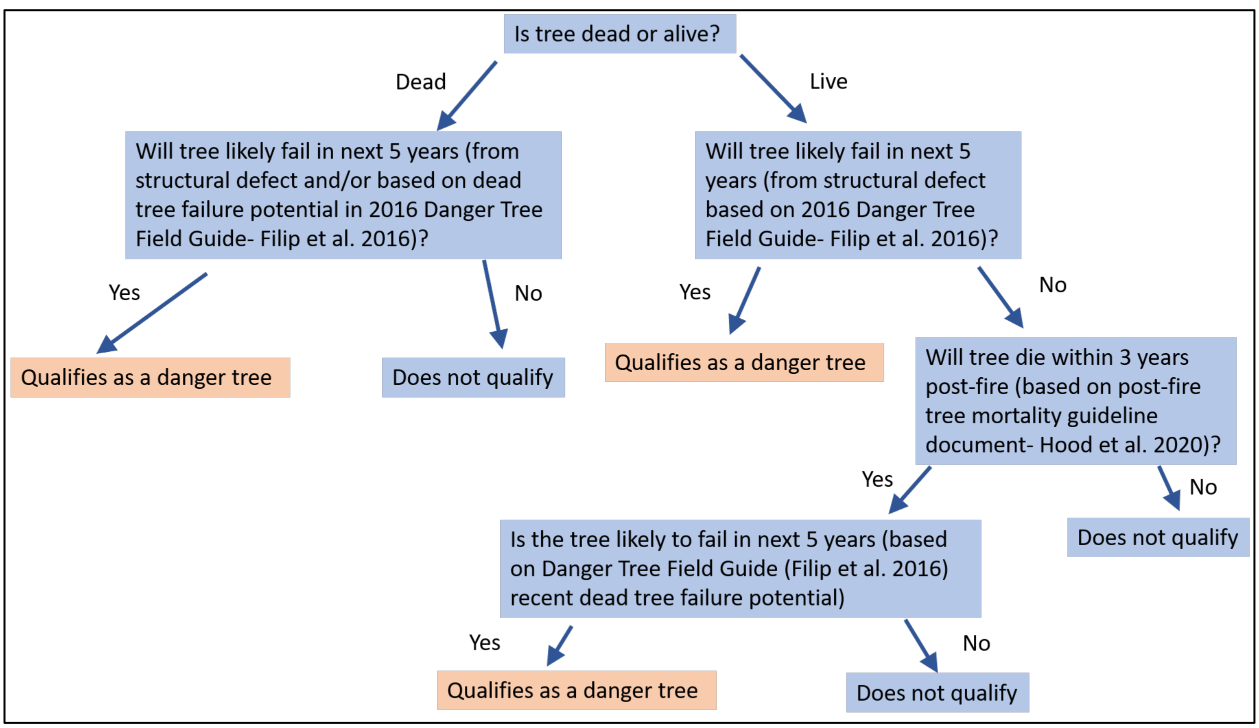


**Figure 3. Decision tree for determination of danger trees after wildfire**

## 7.4. Danger Tree Guidelines

The Pacific Northwest Region of the USDA Forest Service uses the Field Guide for Danger Tree Identification and Response along Forest Roads and Work Sites in Oregon and Washington (Filip et al. 2016) to identify danger trees on Federal lands. Filip et al. (2016) was authored by forest pathologists, logging specialists, and the Regional road engineer. The Field Guide outlines three levels of failure potential (low, likely, and imminent) and describes structural thresholds that lead to failure based on common failure indicators, including fire damage, on tree species in Oregon and Washington. This publication was first developed in 2005 (Toupin and Barger 2005) to assist field going personnel in the workplace and along roads. It was updated in 2008 (Toupin et al. 2008) and again in 2016 (Filip et al. 2016). The first rendition was based on Harvey and Hessburg (1992), which was designed for developed campgrounds. It was then recognized that a more simplistic process was needed to identify danger trees for field going personnel in a variety of work sites.

**The Field Guide for Danger trees outlines three failure potentials:**

- ***Low Failure Potential:*** Trees or their parts are defective or decayed, but it would take considerable effort to make them fail. These trees or parts have a low probability of failure within 10 years.
- ***Likely Failure Potential:*** Trees or their parts are defective or decayed, but it would take moderate effort to make them fail. These trees or parts have a high probability of failure within 3 to 5 years.
- ***Imminent Failure Potential:*** Trees or their parts are so defective or decayed that it would take little effort to make them fail. These trees or parts have a high probability of failure within one year.

The “likely” and “imminent” failure potential timelines in Filip et al. (2016) appear to be in line with FEMA’s guidance to consider imminent hazards within 5 years of the incident.

Table 1 in the Field Guide (Filip et al. 2016, pp. 27-31) lists the failure indicators and their associated failure potentials along with descriptions of low, likely, and imminent. Failure indicators that are relevant to fire damaged trees are outlined below (Table 3), which is an excerpt from Filip et al. (2016; p. 27). Other indicators that may be relevant to fire damaged trees (as listed above) can be found in Appendix E (Table 1 from Filip et al. 2016).

**Table 3. Failure indicators that are relevant to living and dead or dying fire-damaged trees.**

| Failure indicator | Failure potential | | |
|---|---|---|---|
| | **Imminent** | **Likely** | **Low** |
| Old Dead trees (>5 years) No foliage or fine branches; bark is absent or falling off | All tree species except cedar, juniper, and large (>20 in. dbh[1]) Douglas-fir | Cedar, juniper, larch or large Douglas-fir with no other visible indicators | none |
| Recent Dead Trees (<5 years) All or some foliage; fine branches; bark mostly intact | All trees< 10 in dbh | All trees> 10 in. dbh except cedar, juniper, larch, or large Douglas-fir | Cedar, juniper, larch, or large Douglas-fir |
| Living, fire-damaged trees with recent (<5 year) fire damage | True fir, hemlock, spruce or hardwood with >50% of bole cross-section burned & consumed.<br><br>DF, pine, cedar, juniper or larch with >75% of bole cross-section burned & consumed.<br><br>Any species with >1 quadrant burned & consumed structural roots. | True fir, hemlock, spruce or hardwood with 25-50% of bole cross-section burned & consumed.<br><br>DF, pine, cedar, juniper or larch with 50-75% of bole cross-section burned & consumed,<br><br>Any species with 1 quadrant burned & consumed structural roots. | True fir, hemlock, spruce or hardwood with <25% of bole cross-section burned & consumed.<br><br>DF, pine, cedar, juniper or larch with <50% of bole cross-section burned & consumed,<br><br>AND no burned & consumed structural roots. |

1. diameter breast height

## Potential Failure Zone

The potential failure zone is the area on the ground that could be reached by any part of a failed tree. The potential failure zone of a total tree failure is based on several factors, including tree height; ground slope angle- the steeper the slope, the larger the failure zone downhill; and direction of lean if tree is leaning 15 degrees or more. In the USFS Pacific Northwest Region, Engineering Policy FSM R6 supplement 7730-2007-2, the potential failure zone is generally defined as a circle with a radius of 1 ½ times the height of the tree or tree segment, plus additional distance for ground slope and tree lean.

## Failure of dead trees

The potential for failure of recent and older dead trees from Table 3 has guidelines based on tree species and size. These recommendations were developed from an analysis of two separate long-term permanent plot data sets on federal and non-federal lands. These analyses were completed and then incorporated into DecAID. "DecAID" is an advisory system developed from a synthesis of data and research results pertaining to forests in Oregon and Washington. These analyses and documentation and data can be found in the summary information on the DecAID application (https://apps.fs.usda.gov/r6_decaid/views/snag_dynamics.html). Over time, more data has become available and the region plans to re-analyze this data in the near future.

## Post-fire Tree Mortality Research

The Post-fire Tree Mortality Guidelines (Hood et al. 2020) provides injury thresholds for predicting which trees will likely die (see Table 4 below, which is Appendix A in Hood et al. 2020). Trees are considered dead if they have a > 50% likelihood of dying within 3 years post-fire to capture delayed tree mortality. Trees exceeding the listed thresholds are considered dead, even if they have green needles, because they will likely die within 3 years.

The Post-fire Tree Mortality Guidelines are a compilation of the latest research on predicting post-fire mortality and were developed from data collected from Oregon and Washington (Ryan and Reinhardt 1988, Thies et al. 2006, Grayson et al. 2017) and other research on post-fire mortality model predictions and accuracy evaluation (Fowler et al. 2010, Hood et al. 2010, Davis et al. 2012, Thies and Westlind 2012, Hood and Lutes 2017). The majority of data used to develop and assess accuracy of post-fire tree mortality models that are reported in the above-referenced peer-reviewed publications are described in Cansler et al. (2020a) and are publicly available in the Forest Service Research Data Archive (Cansler et al. 2020b). Model performance is described in (Cansler et al. 2020c); see appendices for full descriptions by species. The 3-year estimate was used because that is what the data support – trees were followed for 3 years after fire and logistic regression was used to develop predicted probability of mortality models. Therefore, any estimate FEMA makes of hazard trees following these guidelines will be conservative in that additional mortality could occur between three and five years.

The Post-fire Tree Mortality Guidelines are based, in part, on Forest Service guidelines for the US Department of Agriculture, Forest Service, Pacific Southwest Region (Smith and Cluck 2011) and

Northern Region (USDA Forest Service Region One 2017). The document describes how to determine the levels of fire injury and insect damage that have been shown to be the best indicators of tree mortality. The guidelines use the crown injury indicator of crown scorch, DBH, bark char or cambium injury, and/or the presence or absence of beetle activity indicators to predict mortality.

The likelihood of a tree dying after fire can be assessed by the following indicators:

1. Crown Condition: the percentage of the live crown volume or length that is remaining,
2. Cambium Injury: the cambium mortality at the root collar,
3. Beetle Activity: mass attack or simple presence of bark beetles and wood boring beetles.

The probability that a tree will die after fire depends upon the magnitude of severity of all three factors. More detailed reviews of fire-caused tree mortality are described in (Filip et al. 2007) and (Hood et al. 2018).

### Assessing Fire-caused Injury and Bark Beetle Attacks

Percent crown volume scorch (PCVS) is the percentage of the pre-fire crown volume that is scorched from fire. Crown scorch is generally the most important predictor of tree mortality after fire (Sieg et al. 2006, Woolley et al. 2012). It is determined by first estimating the pre-fire live crown volume, based on remaining live crown, residual scorched foliage, residual burned foliage, and residual branches that have burned but likely had live needles prior to the fire. After estimating what the pre-fire live crown looked like, the percentage of the crown by volume that is scorched is estimated (Hood et al. 2007a).

Bark char is an indicator of the condition of the cambium and determines whether a tree will be able to continue to transport nutrients to roots. Trees with high amounts of dead cambium, but with little crown injury, may take several years to die because the trees can still photosynthesize and transport water up through the xylem, but the connection between the crown and roots is severed. Over time, fine roots die without photosynthates, causing a decline in the tree's ability to transport water to the crown and photosynthesize and eventually the tree dies (Hood et al. 2018). Root injury is not included as a mortality risk factor in the guidelines in the mortality document because it is very difficult to assess. However, if a fire consumed deep duff (>5 inches) that had accumulated around the bases of trees, and root injury is a concern, we direct readers to Hood (2010). Cambium death, caused by high or sustained heating of the tree bole or root collar, is an influential factor in tree mortality following fire. Ryan (1982) states that, in the absence of significant crown injury, most trees survive up to 25% basal girdling, but few trees survive more than 75% girdling. The severity and extent of bark char at the root collar can be used as a surrogate for direct cambium sampling. Estimating bark char to determine if a tree is fire-killed is much faster; however, the accuracy varies by species and not all species have been evaluated (Hood et al. 2008). Table 4 (Hood et al. 2020) provides a crosswalk for bark char codes and probable cambium status by species.

Trees heavily infested by bark and/or wood boring beetles are predicted to die (Goheen and Willhite 2006). Beetle mass-attacks that indicate tree mortality are designated by presence of pitch tubes and/or boring dust around > 50% of the circumference of the lower bole of a tree (Hagle et al. 2003). This is either due directly to the impact of bark beetle infestation and/or indirectly due to trees being so significantly injured that they have become infested by wood boring or ambrosia beetles that only feed in dying and recently dead hosts. The amount of bark beetle and wood boring beetle infestation will determine the potential for mortality even if the tree is not predicted to die based on other injury variables. Some types of beetle attack can indicate a tree may, in fact, already be dead or dying while still appearing alive. Beetle infestation is typically indicated by the presence of pitch tubes or boring dust on the bole or around the base of a tree.

## Determining Immediate and Imminent Mortality

The rubric shown in Table 4 (which is Appendix A of the Post-fire Tree Mortality Guidelines) provides criteria for determining when there is a high likelihood of tree mortality after fire based on the crown condition as estimated by crown scorch, cambium injury based on bark char severity and magnitude, and bark beetle attack severity. The species included in the rubric are ones in Washington and Oregon for which accurate post-fire mortality models exist. If a species is not listed, either no post-fire tree mortality data exist, or the existing evaluated models performed very poorly. The rubric draws on published research of post-fire tree mortality (Ryan and Reinhardt 1988, Thies et al. 2006, Hood and Bentz 2007, Hood et al. 2007b, Hood et al. 2008, Fowler et al. 2010, Smith and Cluck 2011, Grayson et al. 2017, Hood and Lutes 2017). All trees should be evaluated before the beginning of the second post-fire winter, preferably within the first post-fire year. These criteria are a simplification of statistical model predictions.

Once a tree is evaluated if it will likely live or die, the Danger Tree Guidelines ("Recent Dead Trees" in Table 3 above; Filip et al. 2016) can then be used to determine if it is likely to fail within five years of the wildfire.

**Table 4. The rubric shows mortality thresholds using percent crown scorched (either as a percentage of volume or length), circumference and severity of bark char at the root collar, and the bole circumference infested by bark beetles or wood boring beetles. For the rubric, bark char severity is used instead of cambium kill. A tree is considered dead if any criterion is met. (Table from Appendix A in Hood et al. 2020).**

| Species | Criteria | Diameter Class | | |
|---|---|---|---|---|
| | | 5 – 11.9" | 12 – 20.9" | 21"+ |
| ABAM: Pacific silver fir | Crown scorch | > 30% volume | | > 40% volume |
| | Bark char | ≥ 50% any char | | |
| ABCO: white fir or hybrids | Crown scorch | ≥ 70% volume | | |
| | Bark char | ≥ 75% deep char | | |

| | | | |
|---|---|---|---|
| ABGR: grand fir | Crown scorch | ≥ 60% volume | |
| | Bark char | ≥ 50% any char | ≥ 75% moderate or deep char |
| ABLA: subalpine fir | Crown scorch | > 30% volume | > 40% volume |
| | Bark char | > 50% any char | |
| ABMA: red fir | Crown scorch | ≥ 70% volume | |
| | Bark char | > 75% deep char | |
| CADE: Incense cedar | Crown scorch | ≥ 85% volume | |
| | Bark char | > 75% deep char | |
| LAOC: Western larch | Crown scorch | If needles on: ≥ 80% crown length<br><br>If needles off: average char height over entire tree length > 70% | |
| | Bark char | > 75% deep char | Bole char not a predictive injury indicator |
| PIEN: Engelmann spruce | Crown scorch | ≥ 75% volume | |
| | Bark char | > 75% any char | |
| PISI: Sitka spruce | Crown scorch | ≥ 75% volume | |
| | Bark char | > 75% any char | |
| PICO: Lodgepole pine | Crown scorch | ≥ 40% volume | |
| | Bark char | ≥ 75% any char | |
| PIAL: Whitebark pine | Crown scorch | ≥ 40% volume | |
| | Bark char | ≥ 75% any char | |
| PILA: Sugar pine | Crown scorch | ≥ 70% volume | |
| | Bark char | > 90% moderate or deep char | |
| | Crown scorch | > 30% volume | |

| | | | | |
|---|---|---|---|---|
| PIMO: Western white pine | Bark char | ≥ 90% any char | | |
| PIPO: Ponderosa pine | Crown scorch | Pre-bud break (volume):<br>• > 85% needles scorched OR<br>• > 40% needles consumed/blackened OR<br>• > 5% and ≤ 40% needles consumed/blackened combined with >50% needles scorched<br>Post-bud break (volume): > 70% crown volume killed (no new growth) | | |
| | Bark char | > 90% deep char | | |
| PSME: Douglas-fir | Crown scorch | > 65% crown volume | | |
| | Bark char | > 50% deep char | > 75% deep char | |
| THPL: Western red cedar | Crown scorch | > 20% crown volume | > 40% crown volume | > 60% crown volume |
| | Bark char | > 50% any char | | > 75% any char |
| TSHE: Western hemlock | Crown scorch | ≥ 20% crown volume | | |
| | Bark char | ≥ 90% any char | | |
| TSME: Mountain hemlock | Crown scorch | ≥ 20% crown volume | | |
| | Bark char | ≥ 90% any char | | |

Note: If a species is host to bark beetles or wood borers and there is boring dust and attack signs that are not RTB around > 50% of the bole circumference, the tree will die regardless of fire injury.

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# 8. Fish and Wildlife Resources

Shaun Clements and Jennifer Ringo, Oregon Department of Fish and Wildlife
Scott Barndt, USDA Forest Service

## 8.1. Objectives

Document post-fire concerns and management opportunities for fish and wildlife critical values within the Archie Creek, Beachie Creek, Holiday Farm and Riverside Fires.

## 8.2. Assessment Methodology – Field and Modeling

Oregon Department of Fish and Wildlife (ODFW) fish and wildlife biologists combined pre-fire knowledge of fish and wildlife distribution, habitat, and limiting factors with post-fire information such as soil burn severity, vegetation mortality, hazardous materials, and other data to develop maps depicting both threats to critical values and areas where post-fire management could benefit critical values. These maps were compared to recent field data collected by the ETARTs effort to determine any additional threats or opportunities. Additionally, ODFW identified potential negative impacts to Oregon Conservation Strategy (OCS) wildlife priorities from the fires.

## 8.3. Resource Setting

The high value natural resources are found in and around the Archie Creek fire include populations of spring Chinook, summer steelhead, and Pacific lamprey (state sensitive species); cutthroat trout; Roosevelt elk and black-tailed deer, and multiple wildlife strategy species including foothill yellow-legged frog (state sensitive-critical), coastal tailed frog (state sensitive), northern red-legged frog (state sensitive), clouded salamander (state sensitive), northwestern pond turtle (state sensitive-critical), northern spotted owl (federal threatened), great gray owl (state sensitive), Townsend's big-eared bat (state sensitive-critical), and fisher (state sensitive-critical); key strategy habitats including late successional forest, riparian, and oak woodland habitats that support these species; and a fish hatchery supporting freshwater and marine harvest opportunities. Prior to the fire, some of the riparian and stream habitats supporting these values were depauperate of large woody debris (LWD) and/or vegetation suitable for supporting beavers. The Archie Creek Fire burned these habitats with a relatively high percentage of moderate to high soil burn severity.

## 8.4. Critical Values, Results, Risk Assessment, and Recommended Response Actions

Two categories of fish and wildlife Critical Values (CVs) were identified: those determined to be at risk of post-fire threats, and those deemed restoration/natural recovery opportunities. In some cases, ODFW can directly implement actions to address direct threats (e.g. to hatchery water supplies or fish ladders); in all other cases, ODFW will work with partners to address both risks and opportunities.

Six Critical Values (CVs) were determined to be at risk of post-fire threats (2 at high risk), and restoration/natural recovery opportunities were identified for nine additional CVs (8 with high reward; Table 1). ODFW will directly implement actions at Rock Creek Fish Hatchery to address direct threat to the hatchery water supply; in all other cases, ODFW will work with partners to address both risks and opportunities. Conservation Opportunity Areas (COAs) within the fire perimeter are Rock Creek COA (almost entirely) and Umpqua Headwaters COA (partially).

## 8.5. Recommended Monitoring

Near-term success in engaging partners can be monitored by number of projects on which engagement occurs. Over the mid- to longer-terms, success can be measured by habitat variables and populations metrics, such as LWD recruitment into stream channels and escapement of salmonids or population counts of terrestrial wildlife. In addition, partners should prioritize monitoring to increase understanding of species response to fire and post-fire habitat treatments. Likewise, habitats should be assessed over time to determine effectiveness of and responses to treatments, changes in species composition, and presence of invasive species.

**See Appendix F for detailed table of Fish and Wildlife Critical Values, Opportunities and Threats, Risks and Rewards, and Recommendations.**

# 9. Archie Creek ETART Members

### Archie Creek ETART

| Team Member | Resource | Agency |
|---|---|---|
| Simon Apostol | Botany (Weeds) | Cascade Environmental Group |
| Christine Stevenson | Hydrology | Oregon Department of State Lands |
| Brooke Hogan | Soils | USDA Natural Resource Conservation Service |
| Shaun Clements | Fisheries | Oregon Department of Fish and Wildlife |
| Jennifer Ringo | Fisheries | Oregon Department of Fish and Wildlife |
| Bill Burns | Geologic Hazards | Oregon Department of Geology and Mineral Industries |
| Brandon Overstreet | Geologic Hazards | USDI Geological Survey |
| John Hawksworth | GIS | Oregon Department of Forestry |
| Steve Timbrook | GIS | Oregon Department of Forestry |

### ETART Resource Leads

| Team Member | Resource | Agency |
|---|---|---|
| Sarah Callaghan | Botany (Weeds) | USDA Forest Service |
| Megan McGinnis | Soils | Bureau of Land Management |
| Mary Young | Soils | USDA Forest Service |
| Scott Barndt | Fisheries | USDA Forest Service |
| Spencer Higginson | Hydrology | National Weather Service |
| Kyle Wright | Hydrology | USDA Forest Service |
| Barton Wills | Geologic Hazards | USDA Forest Service |
| Kipp Klein | Engineering | USDA Forest Service |
| Paul Claeyssens | Cultural Resources | USDA Forest Service |
| I. Blakey Lockman | Danger/Hazard Trees | USDA Forest Service |

### ETART Coordination Team

| Team Member | Agency |
|---|---|
| Anna Daggett | FEMA |
| Kelsey Madsen | FEMA |
| Katherine Rowden | National Weather Service |
| Daryl Downing | US Army Corps of Engineers |
| Ryan Gordon | Oregon Department of Forestry |
| Cara Farr | USDA Forest Service |
| Dave Callery | USDA Forest Service |
| Terry Hardy | USDA Forest Service |

### ETART GIS Team

| Team Member | Agency |
|---|---|
| Dorothy Thomas | USDA Forest Service |
| David Askov | FEMA |
| Yaw Acheampong | FEMA |
| Sharon Williams | FEMA |
| Joshua Keller | FEMA |
| Sean Carroll | US Army Corps of Engineers |

# Appendix A – Road Treatment Cost Estimates

A total of approximately 8.75 miles of county and private roads within or adjacent to the fire perimeter were examined in detail by ETART Engineering specialists. The following roads were identified of having a risk to property or human life or safety. Other roads within the fire perimeter that were assessed did not pose any potential risks to property or human life and safety.

| ROAD | DESCRIPTION & ISSUES |
|---|---|
| Bar L Ranch Road | ▪ Unpaved self-maintaining private road<br>▪ Provides access to numerous rural residential dwellings.<br>▪ Connects to additional county road: Doe Road<br>▪ **Needs:** storm monitoring and ditch cleaning of all culverts, 3 culvert inlet repairs, 1 culvert replacement<br>▪ Critical values at risk – property |
| Doe Road | ▪ Unpaved self-maintaining private road<br>▪ Provides access to numerous rural residential dwellings.<br>▪ Connects to additional county road: Bar L Ranch Road<br>▪ **Needs:** storm monitoring and ditch cleaning of all culverts<br>▪ Critical values at risk – property |
| Lone Rock Road | ▪ Paved self-maintaining county road<br>▪ Provides access to numerous rural residential dwellings and private forestland, large tracts of BLM land.<br>▪ **Needs:** storm monitoring and ditch cleaning of all culverts<br>▪ Critical values at risk – property |
| Kimmel Lane | ▪ Unpaved self-maintaining private road<br>▪ Provides access to numerous rural residential dwellings.<br>▪ **Needs:** storm monitoring and ditch cleaning of all culverts<br>▪ Critical values at risk – property |
| Skyview Drive | ▪ Paved self-maintaining county road<br>▪ Provides access to numerous rural residential dwellings.<br>▪ **Needs:** storm monitoring and ditch cleaning of all culverts<br>▪ Critical values at risk – property |

| ROAD | DESCRIPTION & ISSUES |
|---|---|
| Rock Creek Road | ▪ Paved self-maintaining county road<br>▪ Provides access to numerous rural residential dwellings and private forestland, large tracts of BLM land.<br>▪ Connects to additional county road: Anabel Road<br>▪ **Needs:** storm monitoring and ditch cleaning of all culverts and repair of several culvert inlets<br>▪ Critical values at risk – property |
| Anabel Road | ▪ Unpaved self-maintaining road (half county, half private)<br>▪ Provides access to numerous rural residential dwellings.<br>▪ Connects to additional county road: Rock Creek Road<br>▪ **Needs:** storm monitoring and ditch cleaning of all culverts and repair of at least 3 culverts<br>▪ Critical values at risk – property |
| Evergreen Drive | ▪ Unpaved self-maintaining private? road<br>▪ Provides access to numerous rural residential dwellings.<br>▪ **Needs:** storm monitoring and ditch cleaning of all culverts and 1 culvert replacement<br>▪ Critical values at risk – property |
| Smith Springs Lane | ▪ Unpaved self-maintaining private? road<br>▪ Provides access to a few rural residential dwellings.<br>▪ **Needs:** monitoring of log jams in North Umpqua River which can cause flooding and bank erosion<br>▪ Critical values at risk – property |

**Proposed Engineering Treatments**

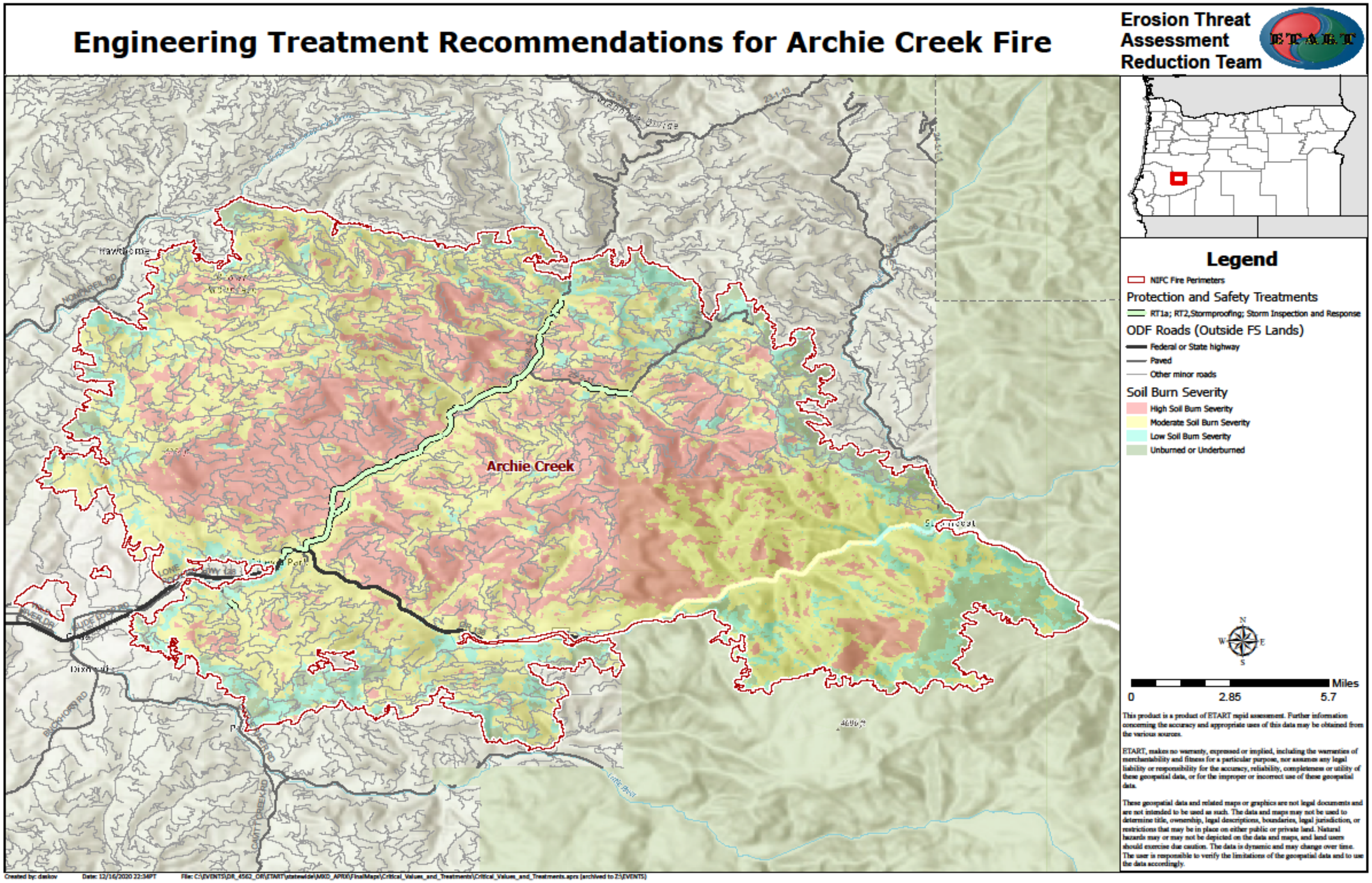
- Bar L Ranch Road - storm monitoring and ditch cleaning of all culverts, 3 culvert inlet repairs, and 1 culvert replacement.
- Doe Road - storm monitoring and ditch cleaning of all culverts.
- Lone Rock Road - storm monitoring and ditch cleaning of all culverts, 2 culvert inlet repairs.
- Kimmel Lane - storm monitoring and ditch cleaning of all culverts.
- Skyview Drive - storm monitoring and ditch cleaning of all culverts.
- Rock Creek Road - storm monitoring and ditch cleaning of all culverts, 2 culvert inlet repairs.
- Anabel Road - storm monitoring and ditch cleaning of all culverts, 2 culvert inlet repairs, and 1 possible culvert replacement.
- Evergreen Drive - storm monitoring and ditch cleaning of all culverts and 1 possible culvert replacement.
- Smith Springs Lane - storm monitoring and ditch cleaning of all culverts.

**Road Treatment Cost Estimates – Archie Creek Fire**

| Mobilization | Qty | Rate | Method | Unit | Total |
|---|---|---|---|---|---|
| Mobilization (Total for all treatments) | 1 | $6,500.00 | LSQ | Lump Sum | $ 6,500.00 |
| **Mobilization Total** | | | | | **$ 6,500.00** |

| Storm Proofing Surveyed Roads | QTY | Rate | Method | Unit | Total |
|---|---|---|---|---|---|
| Clean and Pull Ditches | 8.75 | $750.00 | AQ | Mile | $6,562.50 |
| Clean Culvert Inlets and Outlets | 26 | $250.00 | AQ | Each | $6,500.00 |
| **Treatment Total** | | | | | **$13,062.50** |

| Storm Inspection and Response | Qty | Rate | Method | Unit | Total |
|---|---|---|---|---|---|
| Monitoring crew (2 personnel) | 3 | $900.00 | NA | Day | $2,700.00 |
| Vehicles, Equipment and Misc. | 1 | $15,000.00 | LS | Lump Sum | $15,000.00 |
| **Treatment Total** | | | | | **$17,700.00** |
| **Archie Creek Fire – Road Treatment Total** | | | | | **$37,262.50** |


Engineering Treatment Recommendations for Archie Creek Fire
Erosion Threat Assessment Reduction Team
Archie Creek
Legend
NIFC Fire Perimeters
Protection and Safety Treatments
RT1a; RT2,Stormproofing; Storm Inspection and Response
ODF Roads (Outside FS Lands)
Federal or State highway
Paved
Other minor roads
Soil Burn Severity
High Soil Burn Severity
Moderate Soil Burn Severity
Low Soil Burn Severity
Unburned or Underburned
N
W
E
S
Miles
0
2.85
5.7
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# Appendix B – Supporting Weeds Information, Treatment Design, and Cost Estimates

I. Critical Values Table

II. Treatment Design

III. Cost Estimate

## I. Critical Values Table

| Critical Value | Threat to Value | Probability of Damage | Magnitude of Consequence | Risk | Treatments Considered | Recommended Treatment |
|---|---|---|---|---|---|---|
| Oak Savannah & Woodlands - French Creek Area | Spread of invasive plants into native habitats and loss of habitat and species to high burn severity. | Likely - Significant populations of ODA class A and B weeds are documented within or near the burned area. | Major - Potential expansion of noxious weeds could impact both grazing productivity and habitat value. | Very High | EDRR to survey and control priority weed species within burned area. Monitor low severity burned areas west of drainage (beyond fire line). Explore biocontrol options for common tansy via OR Dept. of Ag. | EDRR to survey and control priority weed species within burned area. Monitor low severity burned areas west of drainage (beyond fire line). Explore biocontrol options for common tansy via OR Dept. of Ag. |

| Critical Value | Threat to Value | Probability of Damage | Magnitude of Consequence | Risk | Treatments Considered | Recommended Treatment |
|---|---|---|---|---|---|---|
| Native Riparian forest communities along Rock Creek and tributaries | Spread of invasive plants into native habitats/loss of habitat and species to high burn severity, resulting in habitat degradation. Sedimentation and erosion of creek channel due to increased runoff from burned areas. | Likely - Disturbance from fire and suppression activities. Disturbance from post-fire salvage logging, and repair activities along Rock Creek road. | Moderate - Dominant hardwoods in riparian areas are more resilient to fire than upland species, but communities will face the threat of sedimentation and noxious weed introduction from nearby roads. | High | Early Detection, Rapid Response to survey and control priority weed species (slender false brome, Armenian blackberry, Scotch broom). Possible targeted tree planting. | Early Detection, Rapid Response to survey and control priority weed species. Monitor native vegetation recovery to determine need and efficacy of replanting. |
| Rock Creek Road (78) corridor Native plant communities | Spread of invasives due to salvage logging operations, fire suppression, fire effects, and road repair construction. | Very Likely - Significant salvage logging traffic on Rock creek road are likely to spread existing populations of weeds along roadsides to new areas, including mapped populations of slender false-brome. | Moderate - Road shoulders and pullouts do not directly represent significant botanical or habitat resources but increase in noxious weed populations here could threaten all other areas due to potential severity and traffic along the road corridor. | Very High | Early Detection, Rapid Response to survey and control priority weed species. Install weed wash station at intersection with Highway 138 | Early Detection, Rapid Response to survey and control priority weed species. Install weed wash station at intersection with Highway 138 |
| Private industrial forest | Spread of invasive plants into tree plantations along roads and during salvage logging activities. | Likely - Disturbance from fire and suppression activities result in bare/exposed soil reducing productivity and creating weed populations that may spread into valuable habitats. | Minor - Presence of noxious weed species can inhibit tree growth however private timber operations already undergo regular weed control efforts. | Low | Install weed wash station at intersection with Highway 138. | Install weed wash station at intersection with Highway 138. |

| Critical Value | Threat to Value | Probability of Damage | Magnitude of Consequence | Risk | Treatments Considered | Recommended Treatment |
|---|---|---|---|---|---|---|
| North Umpqua River - Rock Creek Road to Umpqua NF boundary | Spread of invasive plants in riparian habitat and along highway corridor. | Likely - Disturbance from fire and suppression activities and post-fire tree removal resulting in bare soil and canopy loss. | Minor - Significant weed pressure from the highway existed pre-fire but continued roadside weed treatments may suppress spread. Burn severity lower here than in other areas. | Low | EDRR to survey and control priority weed species particularly slender false brome. | EDRR to survey and control priority weed species particularly slender false brome. |
| Hinkle creek drainage riparian areas | Spread of invasive plants into native habitats and loss of habitat and species to high burn severity. | Possible - Disturbance from fire and suppression activities. Disturbance from post-fire salvage logging, and road repair activities. | Moderate - Dominant hardwoods in riparian areas are more resilient to fire than upland species, but communities will face the threat of sedimentation and noxious weed introduction from nearby roads. SBS and vegetation loss is lower than within the Rock Creek drainage, reducing the potential severity of weed establishment/spread. | Interm ediate | EDRR to survey and control priority weed species (slender false brome, Armenian blackberry, Scotch broom). Possible targeted tree planting. | EDRR to survey and control priority weed species along road corridor (slender false brome, Armenian blackberry, Scotch broom). |

| Critical Value | Threat to Value | Probability of Damage | Magnitude of Consequence | Risk | Treatments Considered | Recommended Treatment |
|---|---|---|---|---|---|---|
| Dry meadows/rock balds/talus slopes - middle elevations | Spread of invasive plants in sensitive habitat post-fire | Possible - Disturbance from fire and suppression activities resulting in bare and exposed soil and rare native plant loss. | Major - Dry meadows & rock balds are rare habitat types with low commercial or recreational use. Rare, endemic plant populations are present in some locations. They are also often difficult to access making weed control and survey harder than in other areas. | High | EDRR to survey and control priority weed species. Monitor mortality and recovery of native species in select sample locations. | EDRR to survey and control priority weed species. |
| Wet meadows/Palustrine Wetlands | Spread of invasive plants in sensitive habitat post-fire | Possible - Disturbance from fire resulting in bare and exposed soil and loss of canopy in forested wetlands. | Major - Fire effects in wetlands west of the cascades are not well documented, but significant changes to the plant community may occur given canopy reduction and exposed soil. | High | EDRR to survey and control priority weed species (common teasel, reed canarygrass, Armenian blackberrry). Possible targeted restoration plantings. | EDRR to survey and control priority weed species, especially in locations near roadways. |

## II. Treatment Design

The analysis in the 2020 ETART Archie Creek Botany report should serve as a starting place for addressing weed threats. Weed detection surveys and treatments should begin Spring 2021 and continue over the next 3-5 years, as resources are available. Weed treatments, including Early Detection and Rapid Response (EDRR), were considered to rehabilitate and recover the Archie fire burn areas. This may include the use of herbicides, biocontrols, and in rare cases, mechanical methods. Rehabilitation of burned and disturbed areas via seeding and planting was also considered in some cases.

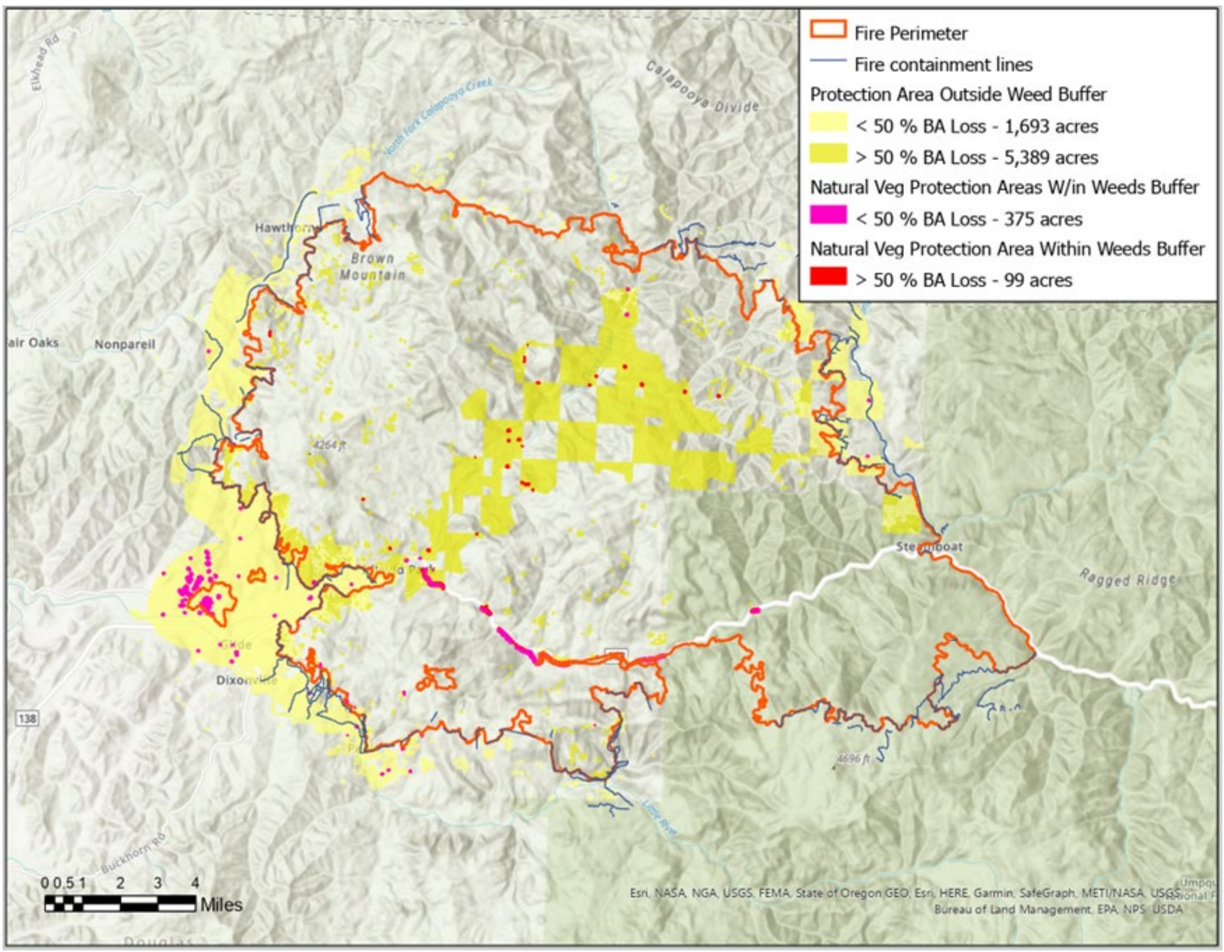


**Figure 7. ETART EDRR Survey and Treatments – Archie Creek Fire**

### Revegetation

Revegetation and restoration efforts are likely to be minor, initially. Any seeding that occurs on roadways or in other disturbed areas should use 100% native plant seeds. Seeding should be prioritized to suppression areas and along high-traffic roadways. Seeding native species in protected areas may hinder the response of existing vegetation, and in areas of rare plants or habitats may be harmful by increasing resource competition. However, seeding of blue wild rye or similar woodland grasses may be useful along fire suppression lines to limit invasive spread, given the possibility of equipment already introducing new weed seeds.

Tree planting needs in the Rock Creek and other riparian areas should be assessed after thorough documentation of canopy mortality during the Spring 2021 growing season. Planting efforts, if required, can then be targeted for winter 2021/2022.

## Monitoring

Initial post-fire assessments should begin the spring of 2021. This can be conducted simultaneously with EDRR surveys. Design protocols to monitor changes to site conditions that occur during the growing season and over longer time frames. A permanent photo point should be established, representing a mix of the habitats and categories represented in the Critical Values Table. Quantitative monitoring of changing plant communities could be useful but may not be feasible given the affected area's scale. During visits to photo points, general qualitative notes on species present and relative abundance are essential to document changing conditions. Annual monitoring visits should also consider whether new factors impact plant communities, such as landslides, grazing, road maintenance, etc. Monitoring should occur for at least 3, but ideally 5-10 years post-fire. Monitoring for two years after the final treatment of EDRR weed species will help document whether treatments are effective.

The Early Detection Rapid Response (EDRR) treatments are designed to protect sensitive native plant communities and supplement remaining native seed banks that promote native plant community recovery. The EDRR survey and treatment actions take into account known weed infestations, sensitive natural habitat types, rare plants, fire suppression lines and existing riparian restoration investments. This assessment identifies response actions to protect native plant communities by reducing the threat of weeds from fire disturbance, fire suppression operations and during post-fire recovery efforts. Cost estimates for implementing these treatments are in Table 8. It is critical to perform EDRR actions in the spring and fall of 2021 to prevent invasive plants from establishing in weed-free burned areas.

Extensive EDRR mapping and treatment of weed populations in all vegetation protection areas is desirable but given resource limitations, priority should be given to monitoring and treatment of areas with the most potential disturbance and possibility to act as pathways for invasive spread, particularly the Rock Creek road corridor and the fire containment lines. If resources allow, EDRR survey and treatment can extend into other critical habitats/resource protection areas.

## ETART EDRR

The assessment identified roughly 99 acres of high-priority EDRR survey and treatment for locations with greater than 50% vegetation mortality, within 50 meters of points where priority weeds have been previously observed. A total of 375 acres of EDRR survey and treatment is also recommended in areas with less than 50% vegetation mortality. EDRR surveys are concentrated within the Rock

Creek road corridor and riparian area (central portion of the fire), along Highway 138 and west of the main fire perimeter. Biocontrol is also recommended for tansy ragwort if suitable populations are located.

## ETART Fire Suppression EDRR

A total of 87.1 miles of fire containment lines were created during fire suppression efforts, including hand lines, dozer lines and vegetation removal along roads (Table 7). The majority of these areas lie outside of the burn perimeter. Ideally, EDRR survey and treatment would be completed for all suppression areas. However, if funds are limited, prioritization should be given to areas with the high SBS as these locations will have lower likelihood for rapid recovery of native vegetation without intervention.

# III. Treatment Schedule and Associated Costs

Given the terrain and the unknown density of weed populations post-burn, it is likely that most weed treatments, with the exception of roadsides, will be done via foot and handheld/backpack sprayer. Access for mechanized equipment is limited, although it may be useful in some cases. For purposes of efficiency and to target weeds during the first growing season, it may be useful to have fully equipped spray crews perform the surveys and treat on the spot if conditions and timing are appropriate. The estimated treatment costs in Table 8 are based on rates for contracted work in the Portland and Salem region and may differ locally. Costs do not include direct supervision, training and certification of EDRR crews.

**Table 7. Fire Suppression Lines and Burn Severity - Archie Creek Fire**

| Fire Suppression Line | Burn Severity | Acres |
|---|---|---|
| Completed Dozer Line | Outside fire perimeter | 38.2 |
| Completed Dozer Line | High | 0.1 |
| Completed Dozer Line | Low | 3.9 |
| Completed Dozer Line | Moderate | 2.0 |
| Completed Dozer Line | Unburned | 3.8 |
| Completed Hand Line | Outside fire perimeter | 0.9 |
| Completed Hand Line | Low | 0.1 |
| Completed Hand Line | Moderate | 0.0 |
| Completed Hand Line | Unburned | 0.3 |
| Road as Completed Line | Outside fire perimeter | 31.1 |
| Road as Completed Line | High | 0.0 |

| Fire Suppression Line | Burn Severity | Acres |
|---|---|---|
| Road as Completed Line | Low | 1.3 |
| Road as Completed Line | Moderate | 0.4 |
| Road as Completed Line | Unburned | 5.0 |
| **Total** | | **87.1** |

**Table 8. Cost Estimates for Invasive Plant and Noxious Weed Treatments - Archie Creek Fire**

| Resource/Area | Treatment | Unit | Cost per Unit | Number | Total Cost |
|---|---|---|---|---|---|
| Natural Vegetation Protection Areas<br>Greater than 50% Mortality | EDRR<br>Survey and Treatment | acre | $250 | 99 | $24,750 |
| Natural Vegetation Protection Areas<br>Less than 50% Mortality | EDRR<br>Survey and Treatment | acre | $250 | 375 | $93,750 |
| Rock Creek Road | Weed Wash Station | each | N/A | N/A | $3,500 |
| Natural Vegetation Protection Areas | Tansy Ragwort Biocontrol (ODA) | | $60 | 60 | $3,600 |
| Suppression Areas Adjacent to Roads or Salvage Harvest | Seeding: blue wild rye grass @ 20 lbs/acre | acre | $200 | ~50 | $10,000 |

# Appendix C – Supporting Soil Information

**I. Soil Types and Erosion Hazard**

**II. Field Indicators of Soil Burn Severity**

**III. Soil burn severity characteristics unique to the Archie Creek Fire**

## I. Soil Types and Erosion Hazard

| Map Unit | Map Unit Name | Taxonomy | Soil Erosion Hazard | Approx. Burn Area Coverage (percent) |
|---|---|---|---|---|
| 90E | Gustin-Orford complex, 3-30 percent slopes | Clayey, mixed, mesic Aquic Palehumults | Moderate | 4.4 |
| 91G | Harrington-Kilchis-Rock outcrop complex, 60-100 percent slopes | Loamy-skeletal, mixed, mesic Typic Haplumbrepts | Severe | 2.8 |
| 97E | Honeygrove gravelly clay loam, 3-30 percent slopes | Clayey, mixed, mesic Typic Palehumults | Moderate | 6.4 |
| 104 F | Ilahee-Mellowmoon-Scaredman complex, 30-60 percent north slopes | Loamy-skeletal, mixed, frigid Typic Haplumbrepts | Moderate | 2.3 |
| 105 F | Illahee-Mellowmoon-Scaredman complex, 30 to 60 percent south slopes | Loamy-skeletal, mixed, frigid Typic Haplumbrepts | Moderate | 2.2 |
| 106 G | Illahee-Rock outcrop complex, 60 to 90 percent north slopes | Loamy-skeletal, mixed, frigid Typic Haplumbrepts | Severe | 1.8 |
| 107 G | Illahee-Scaredman complex, 60 to 90 percent north slopes | Loamy-skeletal, mixed, frigid Typic Haplumbrepts | Severe | 2.2 |
| 122 E | Kinney-Klickitat complex, 3-30 percent slopes | Fine-loamy, mixed, mesic Andic Haplumbrepts | Moderate | 1.4 |
| 124 G | Klickitat-Harrington complex, 60-90 percent north slopes | Loamy-skeletal, mixed, mesic Typic Haplumbrepts | Severe | 11.1 |
| 125 G | Klickitat-Harrington complex, 60-90 percent south slopes | Loamy-skeletal, mixed, mesic Typic Haplumbrepts | Severe | 10.9 |

| Map Unit | Map Unit Name | Taxonomy | Soil Erosion Hazard | Approx. Burn Area Coverage (percent) |
|---|---|---|---|---|
| 126 F | Klickitat-Kinney complex, 30-60 percent slopes | Loamy-skeletal, mixed, mesic Typic Haplumbrepts | Moderate | 13.2 |
| 130 E | Lempira gravelly loam, 3-30 percent slopes | Medial, frigid Typic Hapludands | Moderate | 4.6 |
| 131 F | Lempira-Illahee complex, 30-60 percent north slopes | Medial, frigid Typic Hapludands | Severe | 3.2 |
| 180 E | Orford gravelly loam, 3-30 percent slopes | Clayey, mixed, mesic Typic Palehumults | Moderate | 8.6 |
| 180 F | Orford gravelly loam, 30-60 percent slopes | Clayey, mixed, mesic Typic Palehumults | Severe | 11 |
| 181 F | Orford-Gustin complex, 30-60 percent slopes | Clayey, mixed, mesic Typic Palehumults | Severe | 1.7 |
| 245 E | Thistleburn clay loam, 3-30 percent slopes | Clayey, mixed, frigid Typic Palehumults | Moderate | 1.5 |
| NOT COM | Not mapped | | | 6.1 |
| | Area represented | | | 95.4% |

## II. Field Indicators of Soil Burn Severity

| Indicator | Importance | Low | Moderate | High |
|---|---|---|---|---|
| Ash depth and color | Ash, while nutrient rich, is susceptible to loss through wind and rain | May be black or gray, and ash is shallow. Natural duff remains | Dominantly gray and variable depths. All duff consumed. | Typically gray and white, with areas of deep ash. All duff is consumed, and in some places, reddish oxidized soil may be present on the surface. In some instances, ash is lost from wind erosion during the fire. |
| Soil Char | Indicates soil organic matter consumption in the upper portions of the soil | Nonexistent or very thin | Thin, from 0.5 to 2 cm deep | Thick or variable, with charred soil extending 2 cm and deeper |
| Roots | Live roots may indicate speedier vegetation recovery, while loss of live roots may signal slower recovery | Fine roots are alive, flexible, and intact | Fine roots are brittle or charred, deeper and larger roots may remain viable | Fine roots are entirely consumed. Larger roots may be brittle and charred. |
| Soil Structure | Soil structure provides resistance to erosion from rain drop impacts and overland flow. Loss of structure increases susceptibility to erosion | Soil retains natural structure. | Soil structure may be minimally altered at the surface, but not at depth | Soil structure is lost in the upper surface and has a powdery texture and appearance. |

| Indicator | Importance | Low | Moderate | High |
|---|---|---|---|---|
| Hydrophobicity | Hydrophobicity reduces water infiltration and increases runoff | Naturally present in volcanic ash soils and persisting at depth | Natural hydrophobic properties are minimally altered by heat. May be interrupted at surface, but alterations are patchy and inconsistent | Native hydrophobicity interrupted at soil surface with fire-induced hydrophobicity be present depths more than 4 cm below the soil surface |

## III. Soil burn severity characteristics unique to the Archie Creek Fire.

| Soil Burn Severity | Characteristics |
|---|---|
| Unburned to Very Low | Unburned areas within the fire perimeter and areas where little to no ground fire occurred. Vegetation canopy, ground cover, and soil characteristics are not altered from pre-fire conditions. Occasionally a thin weak layer of water repellency found to occur naturally. |
| Low | Surface organic layer was mostly consumed but some needles, leaves, and small branches are recognizable on the forest floor. Trees and shrubs may be scorched but upper canopy is still intact. Fine roots are present and soil structure is intact. A weak to moderate, thin water repellent layer may be present at the ash-soil interface. |
| Moderate | Surface organic layer is entirely consumed, and a thin layer of ash may remain. Unburned and recognizable charred leaf litter and twigs may remain within a very thin ash layer. Fine roots are present and soil structure is intact. Trees and shrubs are completely scorched but an upper canopy of brown needles is providing needle cast. A moderate to strong, thin water repellent layer is present but discontinuous about 1-2 cm deep. |
| High | Surface organic layer is entirely consumed, and thin to moderate layers of ash may remain. Fine roots may be present but there has been some consumption and soil structure has broken down on the soil surface, and high amounts of soil surface appears orange or red in color. Bare ground is present in over 90 percent of the area. No canopy cover is remaining and there is no potential for needle cast. There is a discontinuous, moderate to strong water repellency layer about 1-4 cm deep. |

# Appendix D – Supporting Geologic Hazards Information

I. Figures and Photos
II. Summary of Critical Values and Geohazards

## I. Figures and Photos

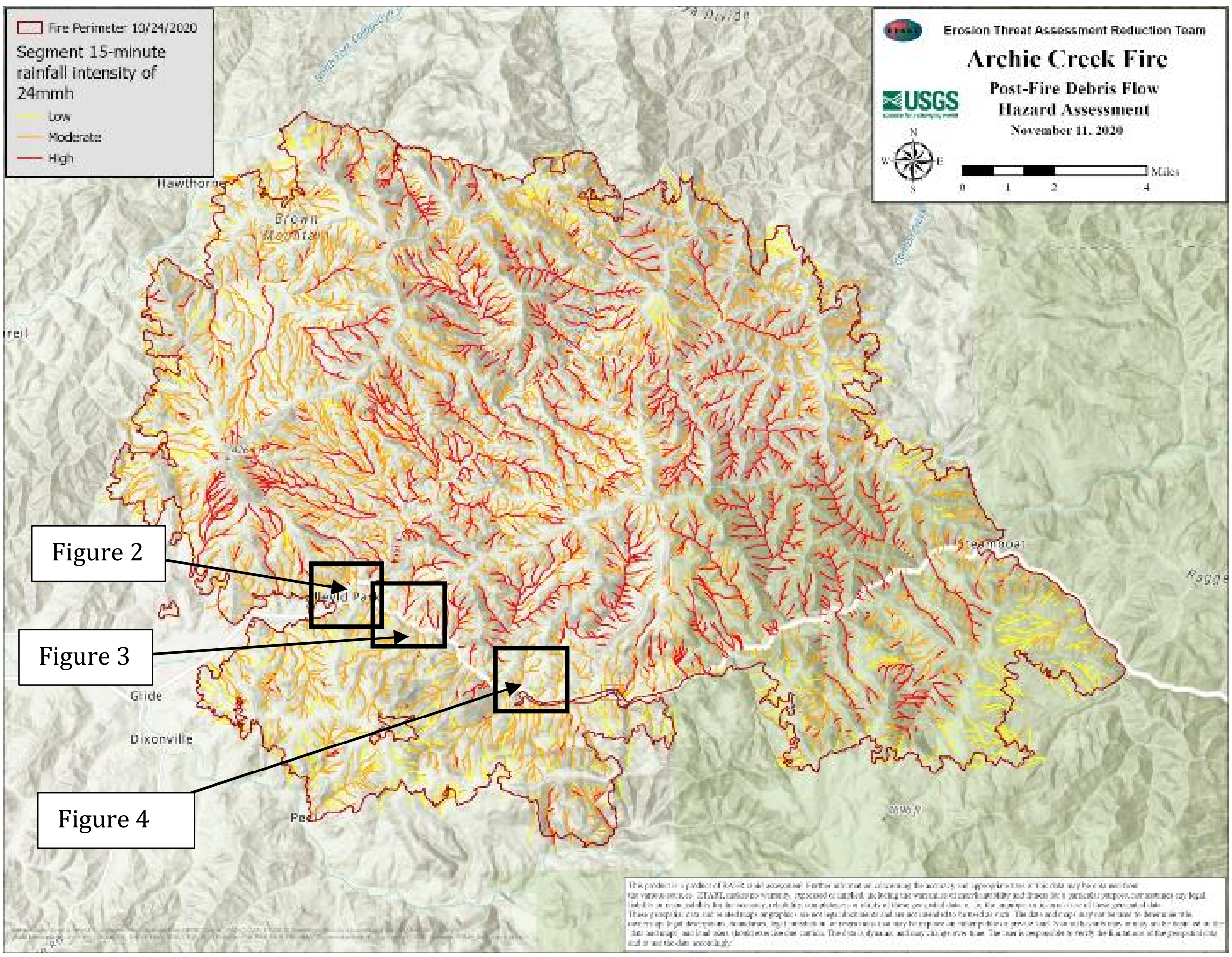


**Figure 1: The map displays estimates of the combined relative debris flow hazard. These predictions are made at the scale of the drainage basin, and at the scale of the individual stream segment. Estimates of combined hazard are based upon a design storm with a peak 15-minute rainfall intensity of 24 millimeters (~1 inch) per hour (mm/h).**

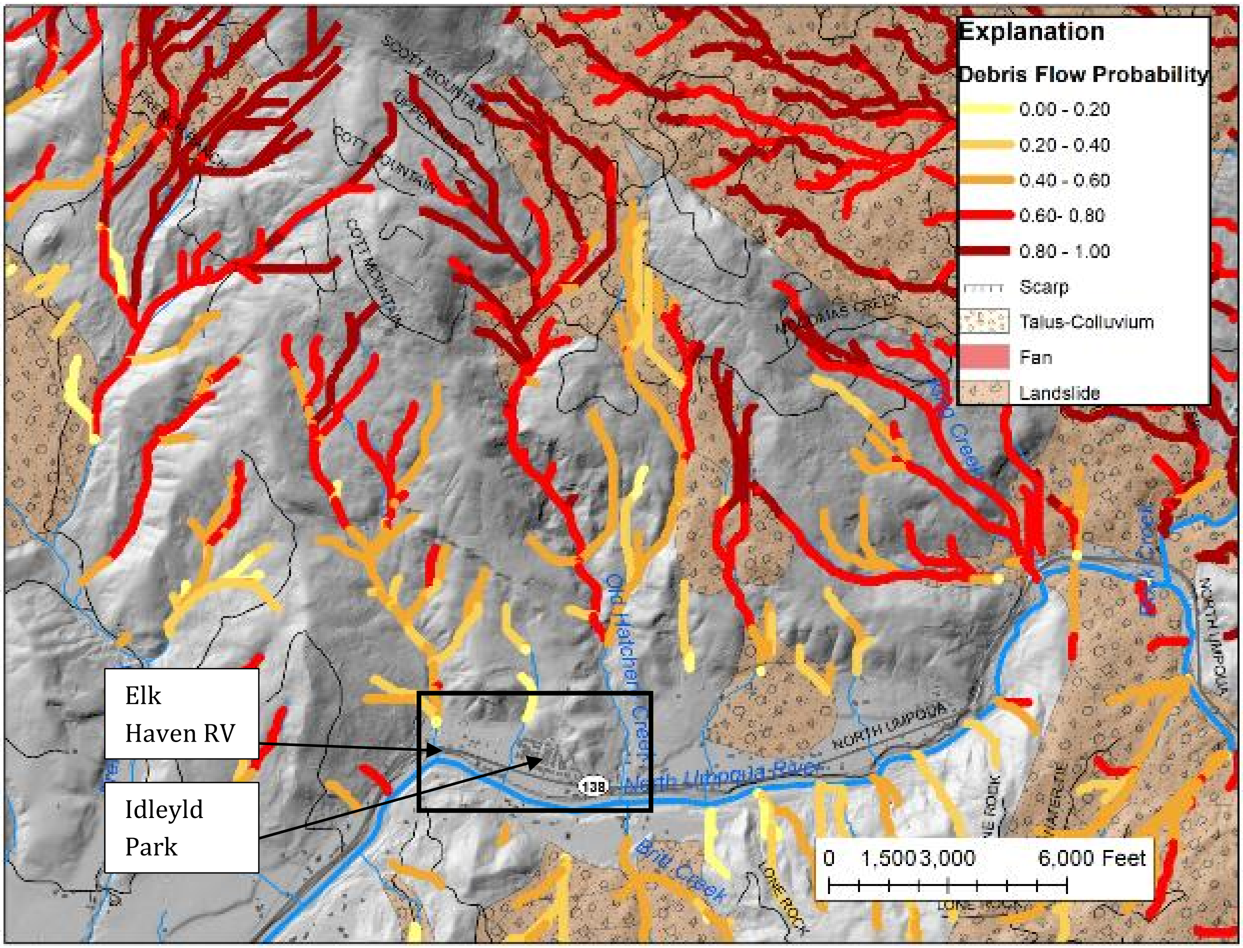


**Figure 2: Town of Idleyld Park and surrounding community is at risk of possible debris flows and reactivation of landslides from the fire. To the west of Elk Haven RV Resort is moderate hazard debris flow potential emanating from drainage area and is located on low gradient fan deposits. Map includes USGS debris flow hazard channels and DOGAMI SLIDO debris flow fans (deposit) areas.**

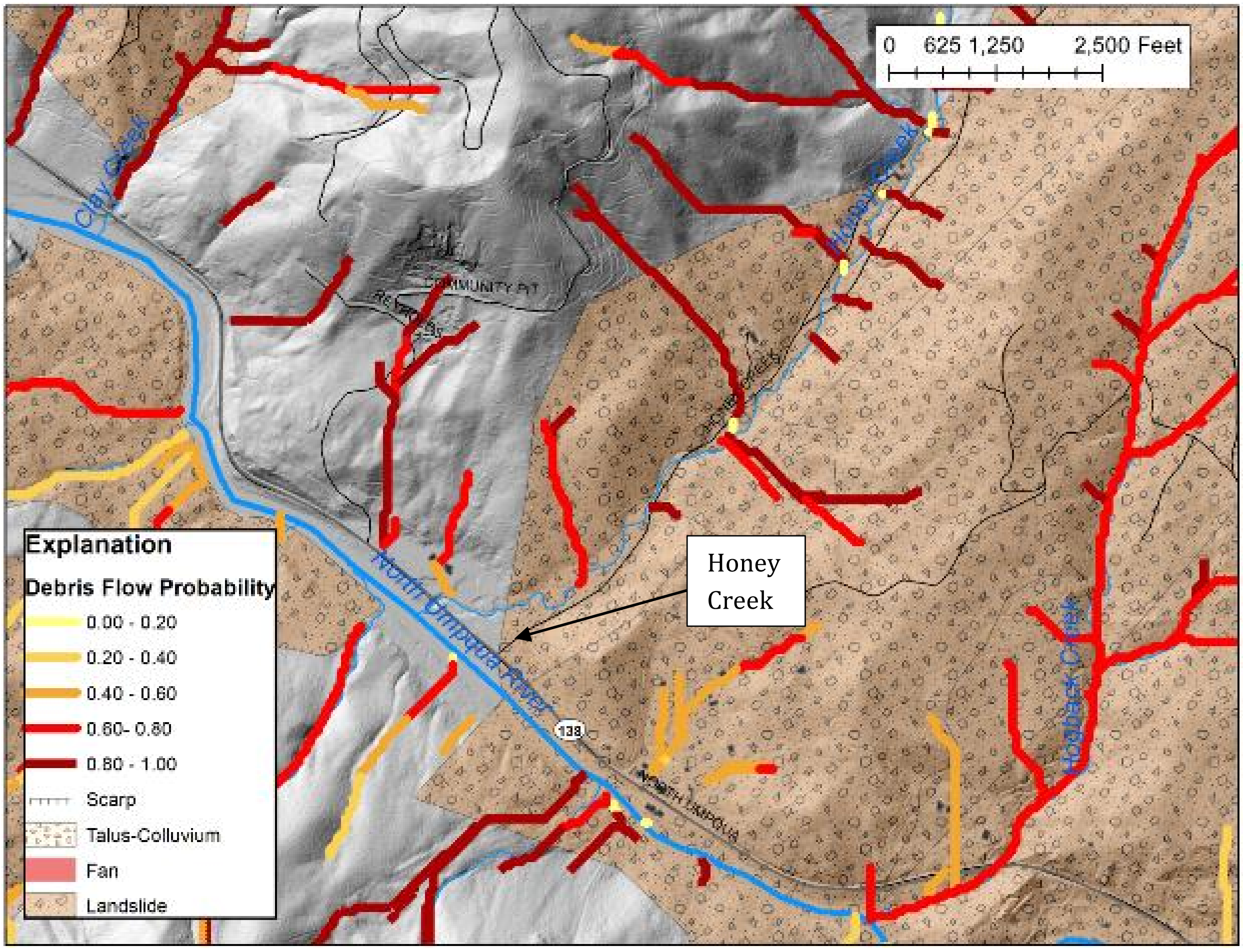


**Figure 4: Dogwood Motel and community around Honey Creek along OR138 are at risk of possible debris flows deposition, rockfall, and reactivation of landslides from the fire. High hazard potential debris flow are possible to enter Honey Creek upstream of the community. The community is also built on deep seated landslide deposits that could reactivate. Map includes USGS debris flow hazard channels and DOGAMI SLIDO debris flow fans (deposit) areas.**


**Photo 1: Rock Creek Hatchery and Rock-Ed education center are at high risk of possible debris flows deposition from channel entering the north side of the facility. Loose rocks will fall during and after rain events.**

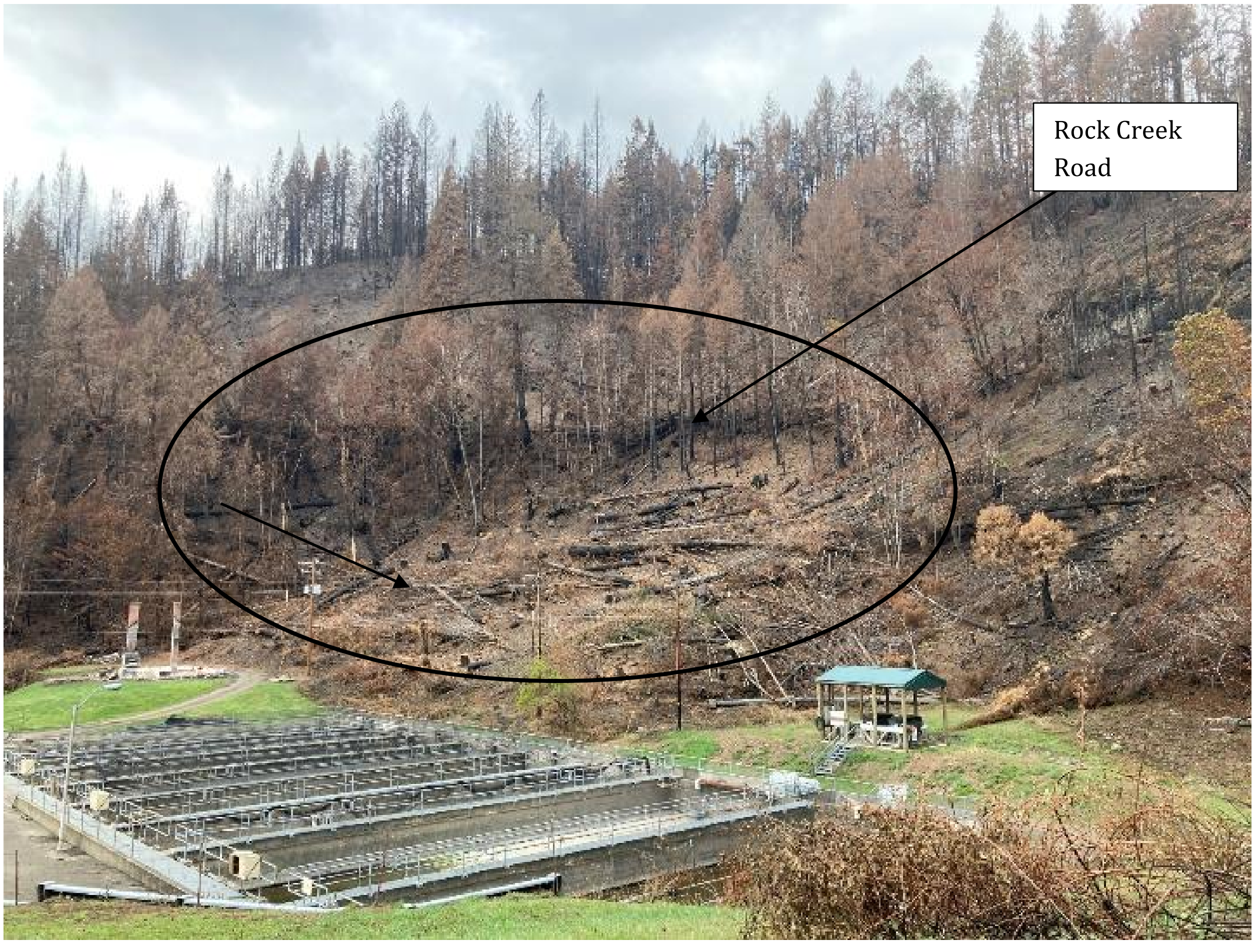


**Photo 2: Rockfall hazards and landslide activation is also of concern at the hatchery. Loose rocks will fall from steep burned slopes during and after rain events. The facility is also constructed on landslide deposits which show pre-fire signs of destabilization. Post fire the slopes may further reactivate.**

**Photo 3: Very steep clear-cut areas along Rock Creek Road which could lead to sedimentation loss, rilling, possible debris flow formation.**


**Photo 4: Example of a debris flow hazard sign that can be placed along roads impacted by the fire. Signs must have large enough letters to be read at driving speed.**

## II. Summary of Critical Values and Geohazards

| Value Description | Owner | Threat to Value | Debris Flow Hazard (1-inch /h of rain in 15 min) | Probability | Magnitude of Consequence | Risk | Risk Reduction Options |
|---|---|---|---|---|---|---|---|
| Rock Creek Hatchery | ODFW | Landslide , Debris flow | High | Likely | Major | Very High | monitor, warning signs, weather alert |
| ▪ Hatchery built on toe of active landslide which is being eroded by Rock Creek. Hilfiger retaining wall along creek supporting toe and slowing erosion. Hatchery also built in deposition zone of debris flows. Most of hatchery burned by fire. Steep slopes directly adjacent to hatchery. | | | | | | | |
| Rock-Ed Outdoor Education Center (located at Hatchery) | Nonprofit | Landslide , Debris flow | High | Likely | Major | Very High | monitor, warning signs, weather alert |
| ▪ Hatchery built on toe of active landslide which is being eroded by Rock Creek. Hilfiger retaining wall along creek supporting toe and slowing erosion. Hatchery also built in deposition zone of debris flows. Outdoor center was not burned by fire. | | | | | | | |
| Swiftwater Park | BLM | None | Very low | Unlikely | Minor | Very Low | warning signs |
| ▪ Park constructed on fluvial deposits at confluence of Rock Creek and North Umpqua River. Debris flow unlikely but hyper-concentrated flow possible | | | | | | | |

| Value Description | Owner | Threat to Value | Debris Flow Hazard (1-inch /h of rain in 15 min) | Probability | Magnitude of Consequence | Risk | Risk Reduction Options |
|---|---|---|---|---|---|---|---|
| Richard Baker Memorial County Park | Douglas County | Debris flow | High | Possible | Minor | Low | warning signs |
| ▪ Steep confined channels, several DF channels intercept park with various levels of hazard. Consequence high if people are present in park | | | | | | | |
| Honey Creek | private homes | Debris flow | High | Possible | Major | High | weather alert |
| ▪ Houses in the channel. | | | | | | | |
| Evergreen Lane & Dogwood hotel | Community | Debris flow, landslide | Moderate | Possible | Major | High | warning signs, weather alert |
| ▪ several buildings at the mouth of channels with moderate df potential | | | | | | | |
| Hogback Creek | private homes | Debris flow | Moderate | Possible | Major | High | weather alert |
| ▪ Houses in the channel. | | | | | | | |

| Value Description | Owner | Threat to Value | Debris Flow Hazard (1-inch /h of rain in 15 min) | Probability | Magnitude of Consequence | Risk | Risk Reduction Options |
|---|---|---|---|---|---|---|---|
| Smith Springs County Park | Douglas County | Landslide , Debris flow | Low | Unlikely | Minor | Very Low | warning signs |
| ▪ several DF channels intercept park with various levels of hazard. | | | | | | | |
| Susan Creek Falls | BLM | Landslide | Very low | Unlikely | Minor | Very Low | monitor |
| ▪ landslide unlikely to damage day use area. | | | | | | | |
| Susan Creek Campground | BLM | Debris flow | High | Possible | Major | High | warning signs |
| ▪ several DF channels intercept campground with various levels of hazard. | | | | | | | |
| Moore Hill Lane | Community | debris flow | High | Possible | Major | High | warning signs, weather alert |
| ▪ several buildings at the mouth of channels with high df potential | | | | | | | |

| Value Description | Owner | Threat to Value | Debris Flow Hazard (1-inch /h of rain in 15 min) | Probability | Magnitude of Consequence | Risk | Risk Reduction Options |
|---|---|---|---|---|---|---|---|
| Rock Creek Road (78) | Douglas County | Landslide, Debris flow | High | Possible | Major | High | monitor, warning signs, weather alert |
| ▪ Rock Creek Road traverses severely burned area of BLM and private land. The slopes are steep, and many slopes are clear cut with no ground vegetation. This large input basin has likely sediment transport and debris flow or hyper-concentrated flow formation. From Idleyld Park to BLM Millpond Rec Site are mapped landslide deposits which could reactivate post fire. | | | | | | | |
| Annabell Rd. and Kelly Creek | private homes | debris flow/Flood | High | Possible | Major | High | warning signs, weather alert |
| ▪ Houses in the channel and in deposition zone with high df hazard | | | | | | | |
| OR138 | ODOT | Landslide, Debris flow | Varies on location | Possible | Major | High | monitor, warning signs, weather alert |
| ▪ The state highway was not specifically analyzed by this report. Dependent on the specific location along the highway, a variety of post-fire geologic hazards are likely including, flooding, erosion, sluffing, dry ravel, rock-fall and debris flows. Communications with ODOT geologist and geotechnical engineers indicate that they are currently planning and addressing rockfall and potential debris flow hazards to the highway corridor. | | | | | | | |
| Town of Idleyld Park | community | Landslide, Debris flow | Mod - High | Possible | Major | High | monitor, warning signs, weather alert |

| Value Description | Owner | Threat to Value | Debris Flow Hazard (1-inch /h of rain in 15 min) | Probability | Magnitude of Consequence | Risk | Risk Reduction Options |
|---|---|---|---|---|---|---|---|
| ▪ community located down stream of df hazards. Located in deposition zone. Further evaluation needed. | | | | | | | |
| Millpond Rec Site | BLM | Debris flow | Moderate | Unlikely | Minor | Very Low | warning sign |
| ▪ Millpond in depositional flat area. DF channel in small basin area. | | | | | | | |
| Lone Pine Group Site | BLM | debris flow | High | Possible | Moderate | Intermed iate | warning sign |
| ▪ Consequence high if people are present in park | | | | | | | |
| Rock Creek Maintenance Facility | BLM | rockfall, debris flow | Moderate | Possible | Moderate | Intermed iate | warning signs, weather alert |
| ▪ Facility in depositional flat area next to very steep rock slope (>75%). DF channel in small basin area. | | | | | | | |
| Rock Creek Rec Site | BLM | Debris flow | High | Possible | Moderate | Intermed iate | warning sign |
| ▪ Campground in depositional flat zone. DF likely to come from east side of campground. | | | | | | | |

| Value Description | Owner | Threat to Value | Debris Flow Hazard (1-inch /h of rain in 15 min) | Probability | Magnitude of Consequence | Risk | Risk Reduction Options |
|---|---|---|---|---|---|---|---|
| Quarry on BLM Road 25-2-11 | private | rockfall, debris flow | High | Possible | Moderate | Intermed iate | weather alert |
| ▪ N/A | | | | | | | |
| Transmission line along OR193 | Private | landslide, Debris flow | Varies on location | Possible | Minor | Low | monitor |
| ▪ Mid-slope, did not evaluate on ground, low-high DF, are towers/poles in channels, if not then unlikely to affect transmission lines, further evaluation needed | | | | | | | |
| Transmission line (south side of fire) | Private | landslide, Debris flow | Varies on location | Possible | Minor | Low | monitor |
| ▪ Did not evaluate on ground, low-high DF, are towers/poles in channels, if not then unlikely to affect transmission lines, further evaluation needed | | | | | | | |
| The Narrows Day Use area | Douglas County | Debris flow | Low | Unlikely | Minor | Very Low | none |
| ▪ very small df basin area | | | | | | | |

| Value Description | Owner | Threat to Value | Debris Flow Hazard (1-inch /h of rain in 15 min) | Probability | Magnitude of Consequence | Risk | Risk Reduction Options |
|---|---|---|---|---|---|---|---|
| Nonpareil Road (northwest side of fire) | Douglas County and house along road | Debris Flow | Low | Unlikely | Minor | Very Low | None |
| ▪ outside of burned area, very low rick of df to road | | | | | | | |

# Appendix E – Supporting Hazard Tree Information

**Table 1. Failure indicators for imminent, likely, and low-failure potentials for trees along forest roads and work sites in Oregon and Washington.**

| Failure Indicator | | Failure Potential | | |
|---|---|---|---|---|
| | | **Imminent** | **Likely** | **Low** |
| Dead Trees | *Old dead trees* (≥5 years) No foliage or fine branches; bark is absent or falling off | All tree species except cedar, juniper, larch, or large (≥20 in. dbh) Douglas-fir | Cedar, juniper, larch, or large Douglas-fir with no other visible indicators | None |
| | *Recent dead trees* (<5 years) All or some foliage; fine branches; bark mostly intact | All trees <10 in. dbh | All trees ≥10 in.dbh except cedar, juniper, larch, or large Douglas-fir | Cedar, juniper, larch, or large Douglas-fir |
| | Recent dead trees in *root disease centers* (p. 59-66) | All tree species except cedar | Cedar | None |
| Roots | Live trees in laminated root rot centers (p. 64)<br>*Phellinus sulphurascens* | Trees with signs or symptoms (ectotrophic mycelium or laminated decay; foliage thinning or yellowing) | Douglas-fir, mountain hemlock, or true firs *without* signs or symptoms and ≤25ft. from an infected tree or stump | Douglas-fir, mountain hemlock, or true firs *without* signs or symptoms and >25ft. from an infected tree or stump;<br>All other species *without* signs or symptoms |

| **Failure Indicator** | | **Failure Potential** | | |
|---|---|---|---|---|
| | | **Imminent** | **Likely** | **Low** |
| | Live trees in Armillaria or Heterobasidion root disease centers<br>*Armillaria* spp. (p. 60) *Heterobasidion*<br>spp. (p. 62) | Trees with signs or symptoms (mycelial fans, resinosis, staining, conks, or wounds with decay; foliage thinning or yellowing) and adjacent (≤50 ft.) to windthrown trees with root disease | Trees with signs or symptoms but not adjacent to windthrown trees with root disease | Trees without signs or symptoms |
| | Live trees in black stain or Port-Orford-cedar root disease centers *Leptographium wageneri* (p. 62) *Phytophthora lateralis* (p. 65) | None | None | All trees |
| | Live trees with undermined or severed roots (p. 66) | Trees with <50% of the structural roots remaining in the ground | Trees with 50 to 75% of the structural roots remaining in the ground | Trees with >75% of the structural roots remaining in the ground |

| Failure Indicator | | Failure Potential | | |
|---|---|---|---|---|
| | | **Imminent** | **Likely** | **Low** |
| Butt | Butt rot (p. 66-69 ) *Schweinitzii* (cow- pie conk) *Tomentosus* (spruce rot conk) *Ganoderma* (artist's and varnish conks) | Trees with ≥1 conk(s) associated with open cracks or exposed decay | Trees with ≥1 conk(s) not associated with open cracks or exposed decay | Trees with butt swell but no conks |
| | Living, fire-damaged trees for recent (<5yr) fire damage; use bole-wounds for old fire damage (p. 70) | True fir, hemlock, spruce, or hardwoods with >50% of the bole cross-sectional area burned and consumed, or more than one quadrant of burned and consumed structural roots<br>Douglas-fir, pine, cedar, juniper, or larch with >75% of the bole cross-sectional area burned<br>and consumed, or more than one quadrant of burned and consumed structural roots | True fir, hemlock, spruce, or hardwoods with 25 to 50% of the bole cross-sectional area burned and consumed, or one quadrant of burned and consumed structural roots Douglas-fir, pine, cedar, juniper, or larch with 50 to<br>75% of the bole cross-sectional area burned and consumed, or one quadrant of burned and consumed structural roots | True fir, hemlock, spruce, or hardwoods with <25% of the bole cross-sectional area burned and consumed, and no burned and consumed structural roots Douglas-fir, pine, cedar, juniper, or larch with <50% of the bole cross-sectional area burned and consumed, and no burned and consumed structural roots |

| **Failure Indicator** | | **Failure Potential** | | |
|---|---|---|---|---|
| | | **Imminent** | **Likely** | **Low** |
| Bole/Stem | Bole wounds mistletoe cankers, fungal cankers, or old fire wounds (≥5 years) (p. 71-80) | True fir, hemlock, spruce, or hardwoods with <50% cross- section of bole with sound wood Douglas-fir, pine, cedar, juniper, or larch with <25% cross-section with sound wood | True fir, hemlock, spruce, or hardwoods with 50 to 75% cross-section of bole with sound wood<br>Douglas-fir, pine, cedar, juniper, or larch with 25 to 50% cross- section with sound wood | True fir, hemlock, spruce, or hardwoods with >75% cross- section of bole with sound wood Douglas-fir, pine, cedar, juniper, or larch with >50% cross-section with sound wood |
| | Frost cracks (p. 82) | None | Trees with weeping cracks | Trees without weeping cracks |
| | Bole cracks (p. 82) | Trees with open splits or cracks with independent movement or exposed rot | Trees with open splits or cracks without movement or exposed decay | Trees with sealed cracks |
| | Burls (p. 82) | None | None | All trees |
| | Quinine conks (p. 86) *Laricifomes officinalis* | Trees with ≥1 conk(s) | None | None |
| | Indian paint fungus conks (p. 92)<br>*Echinodontium tinctorium* | Trees with multiple, large (≥6 in. wide) conks;<br>Single, large conk or multiple, small conks associated with open cracks or exposed rot | Trees with single, large conk or multiple, small conks not associated with open cracks or exposed rot | Trees with a single, small conk |

| **Failure Indicator** | | **Failure Potential** | | |
|---|---|---|---|---|
| | | **Imminent** | **Likely** | **Low** |
| | Red ring rot conks, white speck (p. 90)<br>*Porodaedalea pini* | Trees with ≥1 conk(s) associated with extensive advanced decay[1] such as open cracks or exposed rot | True fir, hemlock, spruce, or hardwoods with ≥1 conk(s) not associated with extensive advanced decay;<br>Douglas-fir, pine, cedar, juniper, or larch with ≥3 large conks (≥6 in. wide) within a 3-ft.-long trunk cylinder | Douglas-fir, pine, cedar, juniper, or larch with ≥3 large conks not within a 3-ft.-long trunk cylinder;<br>≤2 large conks within a 3-ft.-long trunk cylinder;<br>any number or location of small conks |
| | Other heart-rot conks (p. 84-93) | Trees with ≥1 conk(s) associated with open cracks or exposed rot | Trees with ≥1 conk(s) not associated with open cracks or exposed rot | None |
| | Sap-rot conks *Cryptoporus volvatus*<br>(pouch conk) (p. 95)<br>*Fomitopsis pinicola* (red-belt conk) (p.94) | Dead trees with ≥1 red-belt conk(s) | Live trees with ≥1 red-belt conk(s) usually associated with bole wounds | Live trees with ≥1 pouch conk(s); check for extent of dead bark and sound wood |
| Tops and Branches | Forked or multiple tops or stems (p. 97) | Trees with any fork associated with open cracks, decay, or conks*<br>(tops are imminent FP, not the whole tree unless fork is at the base) | Trees with V-shaped forks with embedded bark but not associated with open cracks, decay, or conks*<br>(tops are likely FP, not the whole tree unless fork is at the base) | Trees with U-shaped forks and no open cracks, decay, or conks*; V-shaped forks with no embedded bark, open cracks, decay, or conks*<br>(tops are low FP, not the whole tree unless fork is at the base) |

| Failure Indicator | | Failure Potential | | |
|---|---|---|---|---|
| | | **Imminent** | **Likely** | **Low** |
| | Dead tops or branches (≥3 in. diameter) (p. 96) | True fir, hemlock, spruce, or hardwoods ≥5 years dead or with red-belt conks (tops and branches are imminent FP, not the whole tree) | True fir, hemlock, spruce, or hardwoods <5 years dead; Douglas-fir ≥5 years dead (tops and branches are likely FP, not the whole tree) | Cedar, larch, juniper, or pine; Douglas-fir <5 years dead (tops and branches are low FP, not the whole tree) |
| *Any conk except for red ring rot conks (*P. pini*) on forked Douglas-fir, pine, cedar, juniper, or larch. | | | | |
| Tops and Branches | Detached tops, branches (≥3 in. diameter), or bark (≥1 ft.[2]) (p. 96) | All detached parts (parts are imminent FP, not the whole tree) | Live and attached tops or branches but cracked or split (parts are likely FP, not the whole tree) | None |
| | Dwarf mistletoe brooms (p. 98) | None | Trees with large (≥10ft. in diameter) dead brooms (broom is likely FP, not the whole tree) | Trees with small, dead brooms or live brooms (broom is low FP, not the whole tree) |
| | Cottonwood branches (p. 97) | Trees with large (≥3 in. diam.) dead branches (branches are imminent FP, not the whole tree) | Trees with large, live branches with evidence of decay or past breakage (branches are likely FP, not the whole tree) | Trees with large, live branches with no evidence of decay or past breakage |
| Whole Tree | Broken or uprooted trees supported by other trees (p. 99) | All | None | None |

| Failure Indicator | | Failure Potential | | |
|---|---|---|---|---|
| | | **Imminent** | **Likely** | **Low** |
| | Leaning and/or root-sprung trees (p. 99) | Trees with recent (<5yr) leans ≥15 degrees or old, uncorrected leans with freshly disturbed soil or root damage | Trees with recent leans ≥15 degrees or old, uncorrected leans without freshly disturbed soil or root damage | Trees with old, corrected leans |
| | Height to diameter ratio (p. 100) | Trees with >100 H:D ratio[2] | Trees with 80 to100 H:D ratio | Trees with <80 H:D ratio |
| | Multiple indicators (p. 113) | Two or more likely-FP indicators with synergistic effects: one condition (indicator) worsens the other (i.e. recently killed true fir with a large, Indian paint fungus conk) | Two or more low-FP indicators with synergistic effects (i.e.<br>15% severed roots and an old, corrected lean); two or more likely-FP indicators without synergistic effects (i.e. true fir with a weeping frost crack and a recently killed top) | Two or more low-FP indicators without synergistic effects (i.e. top-killed cedar with two *P. pini* conks on the live bole) |

[1]Firm wood with white speck or firm wood with red discoloration is not considered advanced decay from *P. pini*. Advanced decay is very soft and crumbly.

[2]To calculate H:D ratio, divide the total tree height in feet by the diameter breast height (dbh)

# Appendix F – Fish and Wildlife Values at Risk Table

**Table 1. VAR table**

| Critical Value | Opportunity to Benefit Value | Probability and Rationale | Magnitude of Consequence and Rationale | Reward | Treatment Options Considered | Recommended Treatment |
|---|---|---|---|---|---|---|
| Refugia (Intact Ecosites/Ecosystems) | Intact ecosystems - low burn severity, low vegetation mortality, and low road/trail disturbance factor - are important refugia and source areas, and thus are important to post-fire maintenance and recovery of species. | Likely - Refugia/ecosites with low burn severity and low vegetation mortality are likely very important to species displaced by the fire - particularly late seral obligates - given large areas burned and the extent of moderate to high burn intensity and severity. | Major - Protection of remaining core habitat is critical to retaining source populations of some species, as loss of late successional forest will have long-term effect on species such as the Northern spotted owl. | Very High | Allow for natural regeneration, minimize disturbance, and manage access if necessary | Work with partners to encourage natural regeneration and minimize disturbance to the extent practicable |

| | | | | | | |
|---|---|---|---|---|---|---|
| Standing Dead Wood | Retaining burned wood on the landscape supports a variety of terrestrial species. | Likely - Large areas of high severity fire will result in a high density of snags and woody debris that are used by a variety of terrestrial species. | Moderate - Use of severely burned forest by late successional species such as Northern spotted owl will depend on patch size and availability of unburned or lightly burned habitat nearby. | High | Allow for natural regeneration, limit salvage logging, limit disturbance | Work with partners to encourage natural regeneration and limit salvage to the extent practicable |
| Early-successional Ecosystems | Management of early seral habitat created by these burns (both forest and meadow) can ensure desireable successional pathways, and provide pollinator habitat and deer and elk forage. | Likely - The fire converted large areas of forest to early seral habitat that is vulnerable to invasive species, unregulated vehicle intrusions, other kinds of disturbance, and in some places with high soil burn severity, lack of revegetation. | Moderate - Measures that limit or control invasive species and other kinds of disturbance are critical to recovery of desireable early seral plant species, particularly in areas of moderate to high burn severity. | High | Control invasive species, reseed or revegetate where appropriate, and limit other disturbances such travel management. | Work with partners to prioritize invasive species EDRR*, limit travel vectors, and prioritize revegetation and reseeding as needed for native plants, pollinators, and high forage value. |

| | | | | | | |
|---|---|---|---|---|---|---|
| Security Cover | Limiting motorized vehicle access to newly accessible security cover will protect vulnerable species. | Very Likely - Access to previously closed roads may have opened up due to the burn, exposing areas with reduced hiding cover and sensitive unburned areas. Additional road closures may be needed, particularly if deer and elk populations increase. | Major - Security cover is limiting post-fire, and vehicle access into these habitats compromises security. Some areas previously inaccessible pre-fire are now accessible. Protecting these areas from vehicle intrusions will thus preserve secure habitat. | Very High | Maintain road closures and limit motorized access in areas with habitat providing security cover. | Work with partners to maintain existing road closures and identify need for additional closures to protect or provide security cover. |
| Stable slopes/soil | Mass wasting and soil erosion can result in terrestrial habitat loss and lower water quality. | Possible - Reseeding areas or mulching areas with high soil burn severity, vegetation mortality and risk of debris flow may improve habitat and reduce erosion. | Moderate - Efforts to stabilize slopes could protect habitat from slides. Reseeding roadbeds could reduce erosion and provide valuable forage. | Intermediate | Hill slope treatments, including reseeding where appropriate. | Work with partners to stabilize slopes, reseed where appropriate. |

| | | | | | | |
|---|---|---|---|---|---|---|
| Large Woody Debris (LWD): Various Locations in Rock Creek Basin and Hinkle Creek Basin; Lower portions of Canton Creek, South Fork Calapooya Creek, and Engels Creek | Maintaining standing or dead trees within the riparian zone will be critical to post fire recovery/long term improvement of habitat. As these trees enter the river they create high quality habitat for salmonids | Possible - Variable depending on extent of post fire salvage logging within riparian zone | Major - Many of these systems have historically low levels of LWD, this could potentially reset the system and provide significant long-term benefits in terms of creating suitable habitat for aquatic and terrestrial spp. | High | Alternative salvage logging practices to retain LWD in streams to the extent practicable | Work with partners to encourage salvage logging practices that retain LWD for recruitment into stream channels |
| Riparian Shade: Portions of Rock Creek Basin & lower portions of Honey Creek, Susan Creek, Cougar Creek, Williams Creek, Wright Creek, Fall Creek | Allowing a mix of hardwood/conifer in riparian areas provides more rapid recovery of intermediate shading | Possible - Will be variable depending on burn severity and extent of active management | Major - Many streams within the burn areas have summer temperatures close to thermal tolerance limits-rapid shading from hardwoods may be key to ensuring these streams remain suitable during summer in the near term | High | Reseeding practices and/or natural regeneration practices that will result in riparian shading more quickly | Work with partners to identify alternate reseeding practices and/or natural regeneration for riparian shading |

| | | | | | | |
|---|---|---|---|---|---|---|
| Keystone species | Allowing for some proportion of the riparian area to regenerate with hardwoods provides conditions for beaver to construct dams that benefit a range of aquatic spp | Possible - Will be variable depending on management goals | Major - Beaver are ecosystem engineers that create habitat suitable for many aqautic species, including salmonids. To build dams, beavers require sutiable plant material (typically willow, alder etc) | High | Reseeding practices and/or natural regeneration practices that will result in beaver habitat long-term | Work with partners to identify alternate reseeding practices and/or natural regeneration for long-term beaver habitat |
| Connectivity | Replacement of burned/washed out culverts structures | Likely - Given scale of fires and the number of culverts on the landscape it is likely that some were or will be impacted. | Major - Restoration of passage allows fish to access habitat above these sites | High | Aquatic organism passage options at culvert blockages | Work with partners to identify priorities and options for fish passage at culverts |

| Critical Value | Threat to Value | Probability and Rationale | Magnitude of Consequence and Rationale | Risk | Treatment Options Considered | Recommended Treatment |
|---|---|---|---|---|---|---|
| Water quality (contaminants) – Rock Creek Basin | Runoff from urban areas containing hazardous wastes poses risk to aquatic species | Likely - A number of urban areas were subject to fire damage and are in proximity to waterways. Efforts to remove hazardous wastes are underway but in some instances surface runoff from rains has already occurred or will occur before wastes are removed. | Moderate - Environmentally persistent contaminants that are introduced to waterways may have multigenerational impacts. Other more transient chemicals will likely have impact on 1-2 generations within the area of exposure | Intermediate | Prioritize hazardous waste removal in proximity to waterways | Work with partners to identify prioritize hazardous waste removal in proximity to waterways |
| Water quality (turbidity) | Runoff of ash and sediment represents a near-term threat to spawning success for salmonids and lamprey | Very Likely - A large portion of several watersheds containing spawning habitat for salmon, trout, and lamprey was burned leaving significant ash deposits (source). Control measures will not be sufficient to prevent this from entering waterways during rain events | Minor - Some areas may experience increased redd failure but likely there is sufficient alternate spawning habitat to sustain populations | Low | None | None |

| | | | | | | |
|---|---|---|---|---|---|---|
| Water quality (temperature) | Loss of riparian shading leading to increased stream temperatures | Very Likely - A number of stream reaches experienced complete or partial loss of trees in riparian areas. This will result in increased solar radiation entering streams until vegetation regenerates | Moderate - Temperature increases are likely to last multiple years (potentially 10+ years in high burn severity areas) thereby impacting several generations. In a number of locations that were burnt, stream temperatures during summer were already close to the thermal tolerance limits for fish species. The actual magnitude will depend on future climatic conditions and pace of regeneration (e.g., drought) | Very High | Natural regeneration and/or reforestation with mixed hardwood conifer | Work with partners to encourage natural regeneration and/or reforestation with mixed hardwood conifer |

| | | | | | | |
|---|---|---|---|---|---|---|
| Water quantity (flood) | Increased runoff resulting from lack of vegetative cover may result in higher peak flows leading to increased scour of redds and/or displacement of some species | Likely - A number of watersheds experienced high levels of vegetative mortality and mid/low elevation. Winter forecasts suggest a likelihood of wetter weather. This combination of conditions creates higher likelihood of significant rainstorm/runoff events | Minor - Impacts are likely to be transient (affect 1-2 generations) and spatially heterogenous | Low | None | None |
| Hatchery screen (Rock Creek) | Debris and/or sediment impinging on screen during winter | Likely – Rock Creek watershed experienced a high level of burn severity and vegetation mortality. Likely a lot of ash and debris will enter the river during upcoming winter seasons | Moderate – Depending on extent may have considerable impact on future ability to rear fish on site | High | Regular screen cleaning | Implement regular screen cleaning regimen |

| | | | | | | |
|---|---|---|---|---|---|---|
| Fish Ladder (Rock Creek) | Debris blocking fish passage | Likely - Rock Creek watershed experienced a high level of burn severity and vegetation mortality. Likely for debris to enter the river this winter and in subsequent winters | Minor – Likely to impact ability of fish to move upstream but be transient | Low | Regular ladder cleaning | Implement regular cleaning regimen |
| *EDRR - Early Detection Rapid Response, strategy used for invasive species management | | | | | | |

# Appendix G – Supporting Hydrology Information

## I. Values at Risk Table

| Critical Value | Threat to Value | Probability of Damage or Loss and Rationale | Magnitude of Consequence and Rationale | Risk | Recommended Treatment | Notes |
|---|---|---|---|---|---|---|
| Mouth of Honey Creek (Home and access road) | Debris, slope slumping blocking draining Flow redirected into floodplain | Likely - Steep slopes near narrow channel, no understory | Moderate - Sediment deposition on home footprint and potential water quality impacts | High | Treatment considered: property acquisition | One home in floodplain Steep burned hillslope could result in slumping or rock fall Potential channel diversion and increased overbank flow. Home is burnt and in bad location to rebuild. |
| N. Umpqua Homes on Smith Springs Drive | Existing eddy known to trap debris and logs Increased debris may increase bank erosion | Likely - Already seeing woody debris build up in river | Minor - Bank erosion and nuisance flooding | Low | | 3 homes survived 2-3 homes burned Landowner stated area had flooded in past and there was an eddy near his property where logs and debris accumulate. |

| Critical Value | Threat to Value | Probability of Damage or Loss and Rationale | Magnitude of Consequence and Rationale | Risk | Recommended Treatment | Notes |
|---|---|---|---|---|---|---|
| Fish Hatchery on Rock Creek, Rock-ed Outdoor center | Logs, sediment blocking flow into fish hatchery, upslope debris, debris flow hazard | Likely - High tree mortality upstream, steep slopes | Moderate - Risk of damage but unlikely to be total loss | High | Debris/log clearing, berms/debris diversion structures | Area burned hot. Most homes above the creek. Rock Creek Fish Hatchery is located near the mouth. |
| Fish Hatchery on Rock Creek, Rock-ed Outdoor center | Logs, sediment blocking flow into fish hatchery, upslope debris, debris flow hazard | Unlikely - High tree mortality upstream, steep slopes | Major - Injury or loss of life | Interm ediate | Debris/log clearing, berms/debris diversion structures, early warning system/weather alerts, education | Area burned hot. Most homes above the creek. Rock Creek Fish Hatchery is located near the mouth. |
| Private residences along Bar L Ranch Road & Lone Rock Road | Debris from logs and sediment, burned culvert | Possible - Some hazard trees | Moderate - Risk of property damage from falling trees, impact to road system from burned out culvert | Interm ediate | Hazard tree removal and replace culvert on Bar L Ranch Road | |
| Private residences along Evergreen Road | Debris from logs and sediment, clogged culverts | Likely - Some hazard trees and risk to access roads from plugged ditches and culverts | Moderate - Mixed mosaic burn severity and small contributing area, steep slopes | High | Hazard tree removal and road maintenance | |

| Critical Value | Threat to Value | Probability of Damage or Loss and Rationale | Magnitude of Consequence and Rationale | Risk | Recommended Treatment | Notes |
|---|---|---|---|---|---|---|
| Winchester Dam | Woody debris and sedimentation | Likely - High tree mortality upstream, steep slopes | Moderate - Structure is designed to have flow overtop the dam. Debris will stack up against the dam but should flow over during high water | High | Update EAP to account for woody debris. Remove any logs that threaten the water intake structure or the fish ladder at the ends of the dam. | |

## II. Soil Burn Severity by Watershed

| Subwatershed Name | Total Subwatershed | | Outside Fire Perimeter | Unburned | | Low | | Moderate | | High | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Acres | % Burned | Acres | Acres | % | Acres | % | Acres | % | Acres | % |
| Lower Canton Creek | 34601 | 10.2% | 27191 | 3883 | 11.2% | 2018 | 5.8% | 1379 | 4.0% | 130 | 0.4% |
| Lower Steamboat Creek | 33115 | 0.1% | 33054 | 12 | 0.0% | 23 | 0.1% | 26 | 0.1% | | 0.0% |
| Panther Creek | 24325 | 7.9% | 20364 | 2037 | 8.4% | 1380 | 5.7% | 538 | 2.2% | 6 | 0.0% |
| Apple Creek-North Umpqua River | 23453 | 15.4% | 17939 | 1910 | 8.1% | 2073 | 8.8% | 1481 | 6.3% | 51 | 0.2% |

| Subwatershed Name | Total Subwatershed | | Outside Fire Perimeter | Unburned | | Low | | Moderate | | High | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Williams Creek-North Umpqua River | 24799 | 79.4% | 4238 | 873 | 3.5% | 3058 | 12.3% | 11339 | 45.7% | 5291 | 21.3% |
| Thunder Creek-North Unpqua River | 33164 | 71.7% | 8303 | 1068 | 3.2% | 2154 | 6.5% | 11653 | 35.1% | 9986 | 30.1% |
| Susan Creek-North Umpqua River | 33978 | 89.1% | 1909 | 1806 | 5.3% | 3709 | 10.9% | 14686 | 43.2% | 11867 | 34.9% |
| Upper Rock Creek | 47658 | 28.2% | 32110 | 2089 | 4.4% | 3175 | 6.7% | 6106 | 12.8% | 4178 | 8.8% |
| East Fork Rock Creek | 28619 | 88.2% | 1211 | 2164 | 7.6% | 4121 | 14.4% | 10141 | 35.4% | 10981 | 38.4% |
| Lower Rock Creek | 49091 | 99.9% | | 48 | 0.1% | 1426 | 2.9% | 18472 | 37.6% | 29145 | 59.4% |
| Emile Creek | 161 | 11.7% | 135 | 7 | 4.0% | 12 | 7.2% | 7 | 4.6% | 0 | 0.0% |
| Middle Little River | 31 | 80.6% | 4 | 1 | 4.8% | 11 | 35.1% | 13 | 41.5% | 1 | 3.9% |
| Lower Little River | 15 | 81.5% | 2 | 1 | 5.7% | 5 | 31.4% | 5 | 35.9% | 2 | 14.1% |
| Bradley Creek-North Umpqua River | 11352 | 71.1% | 2719 | 561 | 4.9% | 1714 | 15.1% | 4451 | 39.2% | 1906 | 16.8% |

| Subwatershed Name | Total Subwatershed | | Outside Fire Perimeter | Unburned | | Low | | Moderate | | High | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Headwaters Calapooya Creek | 19428 | 23.1% | 14145 | 789 | 4.1% | 789 | 4.1% | 2766 | 14.2% | 939 | 4.8% |
| Hinkle Creek-Calapooya Creek | 23497 | 47.0% | 12099 | 362 | 1.5% | 1254 | 5.3% | 6657 | 28.3% | 3127 | 13.3% |
| Gassy Creek-Calapooya Creek | 25460 | 7.9% | 22843 | 617 | 2.4% | 756 | 3.0% | 1082 | 4.2% | 163 | 0.6% |
| **Grand Total** | **412746** | **47.5%** | **198266** | **18227** | **4.4%** | **27677** | **6.7%** | **90803** | **22.0%** | **77772** | **18.8%** |

## III. USGS Gauge Stations within the Burned Perimeter

| USGS Gauges Archie Creek Fire | | | | | |
|---|---|---|---|---|---|
| **Gauge Location** | **Site Number** | **Watershed** | | | **Notes** |
| N. Umpqua River above Copeland Creek near Toketee Falls, OR | 14316500 | North Umpqua | Archie Creek | SW, WQ | Repaired post fire |
| N. Umpqua River near Idleyld Park, OR | 14317450 | North Umpqua | Archie Creek | WQ | Repaired post fire |
| Steamboat Creek Near Glide | 14316700 | North Umpqua | Archie Creek | SW | Repaired post fire |

| USGS Gauges Archie Creek Fire | | | | | |
|---|---|---|---|---|---|
| Rock Creek Near Glide, Oregon | 14317600 | North Umpqua | Archie Creek | SW | Threatened |
| Little River at Peel, Oregon | 14318000 | North Umpqua | Archie Creek | SW | Treatened |

# IV. Streamflow and Storm Analysis Peak Flow Modeling

Regional regression equations were used in order to estimate pre-fire peak flows for western Oregon streams. The prediction equations were developed for estimating peak discharges at ungaged sites for various return intervals by relating peak discharges to physical and climatological watershed characteristics (Cooper, 2005). The equations are valuable for estimating peak flows in rural, unregulated drainages which derive a significant portion of their streamflow from storm runoff and/or snowmelt and are a commonly accepted method for estimating peak flows in ungaged basins. Regression equations were developed specific to hydrologic regions defined by the processes which largely influence peak flows, such as rain only, snowmelt, and/or rain-on-snow. Watersheds within each hydrologic region show similar flood frequency relationships, and display similarities in watershed, geomorphological, and meteorological characteristics. It is important to note that prediction equations do not account for reservoir operations, diversions, or urbanization, and the estimates of peak flows represent a hypothetical situation of the watershed, not the actual condition. For further discussion of the assumptions, methodologies, and errors associated with the prediction equations, refer to Cooper (2005).

Basins were delineated for poursheds of interest, which typically contained critical values that required further assessment to understand elevated risk associated with increased peak flows. ArcGIS was used to delineate basins and extract watershed characteristics. The methodology developed by Cooper (2005) contains equations to estimate instantaneous peak flows with annual exceedance probabilities of 50, 20, 10, 4, and 2 percent, corresponding to recurrence intervals of 2, 5, 10, 25, and 50 years, respectively. Given the setting of the burned areas in the upper McKenzie and Calapooia watersheds, equations 1 and 2 were used to estimate pre-fire peak flows (2-year return interval) for watersheds with mean elevations below and above 3000 feet:

Elev<3000 ft:

$$Q_2 = 10^{0.9607}Area^{0.9004}Slope^{0.4695}I_{24\text{-}2}{}^{0.8481} \qquad [1]$$

Elev>3000 ft:

$$Q_2 = 10^{-2.506}Area^{1.021}Slope^{0.8124}I_{24\text{-}2}{}^{2.050}MinJanTemp^{3.541}MaxJanTemp^{-1.867} \qquad [2]$$

where Area = drainage area (sq mi), Slope = mean watershed slope (degrees), $I_{24\text{-}2}$ = 2-year, 24-hour rainfall intensity (inches), MinJanTemp = mean minimum January temperature (degrees F), and MaxJanTemp = mean maximum January temperature (degrees F). Coefficients were also calibrated to develop additional equations for estimating peak flows at return intervals of 5, 10, 25, and 50 years for each region (see Cooper, 2005). In circumstances where a stream gage is located on the same stream as the ungaged watershed of interest, and the gaged watershed is between 50 and 150 percent of the ungaged watershed area, it is advised that peak discharges for ungaged watersheds, $Q_u(T)$, be determined directly from peak discharges for the gaged watershed using equation 3:

$Q_u(T) = Q_g(T)*(A_u/A_g)^{Ca(T)}$ [3]

where $Q_a(T)$ = peak discharge for gaged watershed at return interval T (cfs), $A_u$ = area of ungaged watershed (sq mi), $A_g$ = area of gaged watershed (sq mi), and $C_a(T)$ is the coefficient for area for the specified hydrologic region and return interval T.

Post-fire peak flows were estimated by modifying pre-fire peak flow estimates based on the weighted area of low, moderate, and high soil burn severity. $Q_{50}$ was applied to high burn severity, $Q_{25}$ was applied to moderate burn severity, and the area of low burn severity was split evenly between $Q_{10}$ and $Q_5$ peak flows ([USDA, 2009]; note: $Q_n$ represents the discharge in cubic feet per second associated with the n-year recurrence interval). Post-fire peak flows at the 2-year and 5-year recurrence intervals were estimated using equations 4 and 5:

$Q_{2post} = (\%Area_{unburned})(Q_2) + (\%Area_{low})(Q_5) + (\%Area_{mod}/2)(Q_5) + (\%Area_{mod}/2)(Q_{10}) + (\%Area_{high})(Q_{10})$ [4]

$Q_{5post} = (\%Area_{unburned})(Q_5) + (\%Area_{low}/2)(Q_5) + (\%Area_{low}/2)(Q_{10}) + (\%Area_{mod})(Q_{25}) + (\%Area_{high})(Q_{50})$ [5]

Where %Area represents the percent of watershed area classified based on soil burn severity (i.e. unburned/outside, low, moderate, or high) and $Q_n$ represents the pre-fire peak flow at the specified return interval.