Beachie Creek Fire

Erosion Threat Assessment/Reduction Team (ETART)
Extended Report

December 2020

FEMA

This page intentionally left blank.

Table of Contents

Executive Summary

This report summarizes a rapid characterization of post-fire conditions resulting from the Beachie 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 Beachie 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 Beachie Creek Fire perimeter, including some adjacent areas within the Lionshead fire around Detroit Lake. 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.

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 (OEM) 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: Beachie Creek
- State: Oregon
- Date Fire Started: August 16, 2020
- Date Fire Contained: October 31, 2020 (estimate, ICS-209 dated 10/23/2020)
- Suppression Cost: $30,000,000 (estimate, ICS-209 dated 10/23/2020)
- Fire Number: OR-WIF-200299
- County: Clackamas, Linn and Marion

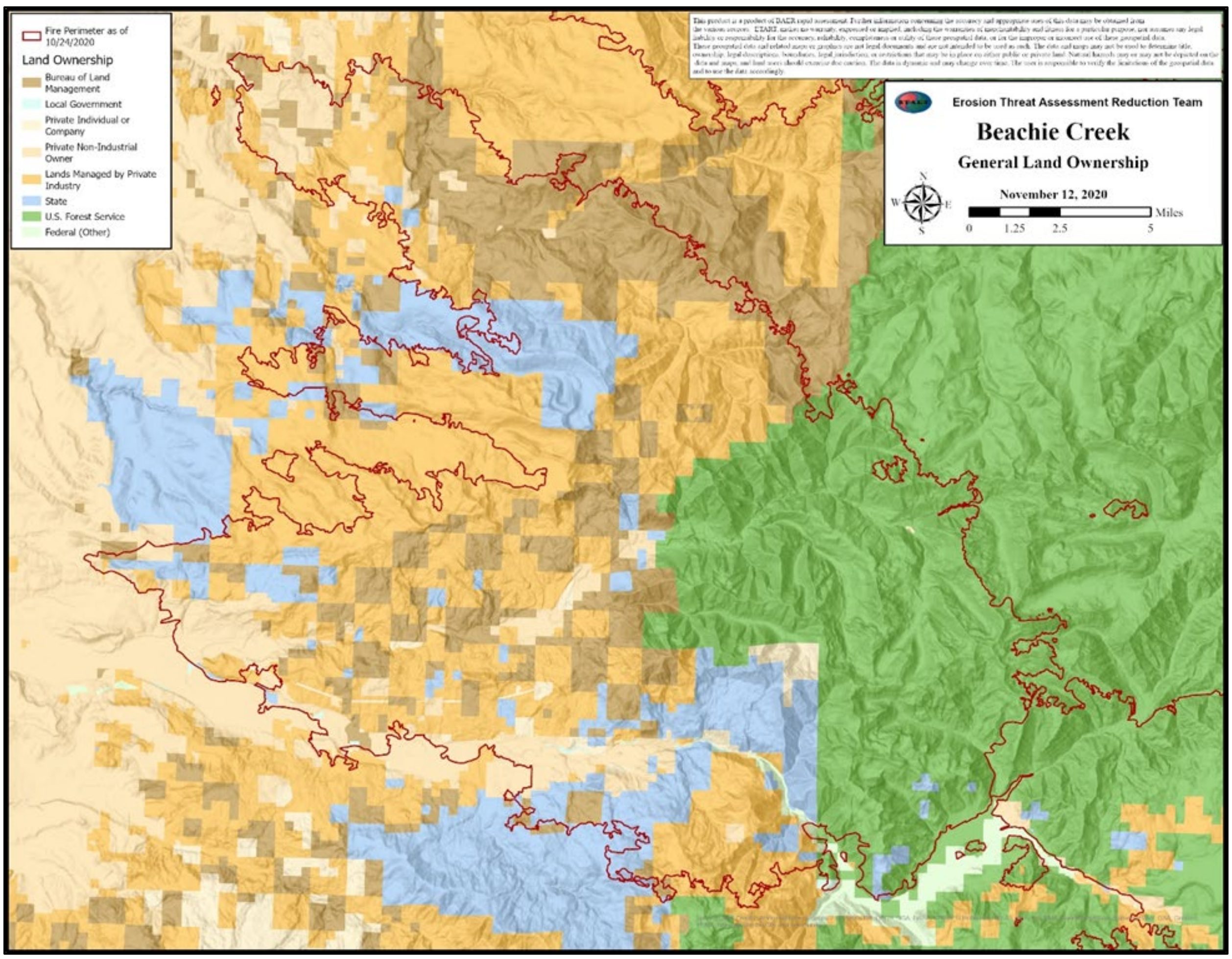


Figure 1. Land Ownership - Beachie Creek Fire

The Beachie Creek Fire was first detected on August 16, 2020, approximately two miles south of Jawbone Flats in mountainous terrain in the Opal Creek Wilderness, Willamette National Forest. The fire size was about 20 acres for seven days, growing slowly to roughly 200 acres by September 1. Fueled by hot and dry conditions, the fire grew to about 500 acres over the next five days. On September 6, the National Weather Service placed Northwest Oregon under a critical fire weather warning due to the confluence of high temperatures, low humidity and rare summer easterly winds that were predicted to hit upwards of 35 mph in the Portland area on Labor Day (September 7). The weather event on September 7 generated 50-75 mph winds, creating an extreme climate environment which radically influenced fire behavior and accelerated fire progression to a growth rate of just under 3 acres per second in areas of the Beachie Creek fire. This caused the fire to burn over 130,000 acres in one night, resulting in rapid spread onto the Mt. Hood National Forest, BLM lands, State of Oregon and privately-owned lands. The Beachie Creek Fire heavily impacted several communities in the North Fork Santiam River and Little North Santiam River drainages including Jawbone Flats, Elkhorn, Gates, Mill City, Lyons/Mehama and portions of the Detroit Lake community.

Table 1. Beachie Creek Fire Total Acres Burned – 193,566 (based on post-fire analysis perimeter)

Ownership	Acres	Sq.Mi.	Percent
Local	229	<1	<1%
Private	78,788	123	41%
State	24,111	38	12%
Tribal	0	0	0%
Federal	90,438	141	47%

Table 1. Beachie Creek Fire – Acres Burned by County

Clackamas County	Acres	Sq.Mi.	Percent
Local	0	0	NA
Private	20,414	32	45%
State	5,192	8	11%
Tribal	0	0	0%
Federal	20,104	31	44%

Marion County	Acres	Sq.Mi.	Percent
Local	116	<1	<1%
Private	48,110	75	36%
State	14,150	22	11%
Tribal	0	0	0%
Federal	68,850	108	52%

Linn County	Acres	Sq.Mi.	Percent
Local	112	<1	1%

Linn County	Acres	Sq.Mi.	Percent
Private	10,265	16	61%
State	4,669	7	29%
Tribal	0	0	0%
Federal	1,484	2	9%

1.1.1. CLIMATE

The climate within the Beachie Creek fire varies by elevation and is regarded as a Mediterranean climate. The annual average precipitation ranges varying from 60 inches in the lower elevations to 114 inches at the higher elevation areas in the eastern portions of the fire. Almost all precipitation falls between October and May, due to Pacific maritime frontal storms dominated by 5 – 10 inches of rain over 18 to 36-hour periods from October through January. Snowfall accumulation begins in higher elevations from mid to late November continuing through April. Rain-on-snow events are common, typically occurring from November through January.

1.1.2. GEOLOGIC TYPES

The burned area is located in the Cascade Mountains geologic province. The Cascade Range is divided into two physiographic sub provinces: Western Cascades and the High Cascades. The bedrock geology is primarily comprised of Pliocene to Quaternary igneous extrusive rocks: basalt, basaltic andesite, dacite, and rhyolite. There are continental and marine sedimentary rocks located along the western margin of Beachie Creek burned area. Surficial deposits consist of unconsolidated alluvium, terrace deposits, fluvial glacial, glacial till, rockslide, landslide and debris flow deposits. Landslides are a widespread and damaging natural hazards in Oregon. The general term “landslide” refers to a range of mass movements including rock falls, debris flows, earth slides, and other mass movements. In the Cascades, debris flows and related flash flooding/hyper concentrated flow events, rock fall, shallow and deep landslides are the most common types of landslides.

1.1.3. DOMINANT SOILS

Soils in the burned area originate from the volcanic rock types that are resistant to weathering and erosion. Surface soil textures are silt loam, loam, or clay loam. The upland soils commonly form from glacial deposits, colluvial materials, residuum, and landslides. Soils range in rock fragment content across the region. Typically, the skeletal soils are associated with glacial deposits and colluvial deposits. Rock outcrops and screes occur on steeper areas and mountain slopes. Soils with andic soil properties are common throughout the region. The landscape of this region features steep hillslopes having a natural tendency to slough material, this is due to the geology, soil textures and climate.

1.1.4. VEGETATION TYPES

The vegetation communities within the Beachie Fire area are comprised of Douglas-fir/western hemlock (65%), Douglas-fir/true fir (13%), Mixed conifer (13%) with higher elevations dominated by true fir (1.6%) and mountain hemlock (0.6%). Understory vegetation varies by aspect, elevation and canopy cover, with Oregon grape (Mahonia nervosa), salal (Gaultheria shallon) and rhododendron (Rhododendron macrophyllum) being the most common shrub species under Douglas fir associations, sword fern (Polystichum munitum), ocean spray (Holodiscus discolor) and vine maple (acer circinatum) under western hemlock, and white fir associations and at higher elevations with primarily beargrass (Xerophyllum tenax), huckleberry (Vaccinium sp) and swordfern (Polystichum munitum). Non-forested sites comprise 5% of the fire area and include lava flows, wetlands, hardwoods, rock gardens as well as a diverse forb dominated meadow communities. These meadow systems comprise a mosaic of special habitats within a forested landscape that are often comprised of unique plant communities which include rare or sensitive plant species.

1.1.5. WATERSHEDS (5TH LEVEL HYDROLOGIC UNITS)

Major drainages in the burned area include portions of the Little North Santiam River, North Santiam River, Cedar Creek, Elkhorn Creek, Opal Creek, and French Creek. Elevations in the burned area range from about 800 feet above sea level at the west end of the fire to 5,200 feet at Mount Beachie. The percent area burned for the watersheds are summarized in Table 2 and displayed Figure 2.

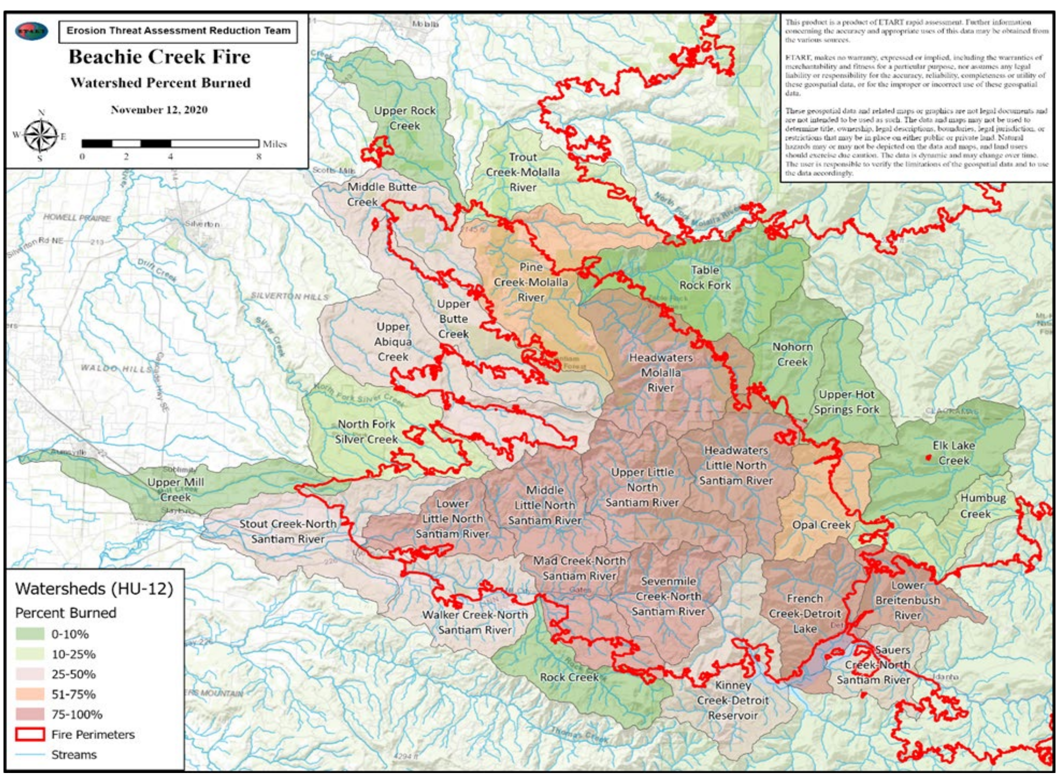


Figure 2. Watersheds Percent Area Burned - Beachie Creek Fire

Table 2. Affected Watersheds (HUC10 and 5th Level Hydrologic Unit Name)

HUC10	Watershed Name	Total Acres	Acres Burned	% of Watershed Burned
1709000501	Breitenbush River	69,326	1,564	2.3%
1709000502	Headwaters North Santiam River	146,501	45	<0.1%
1709000503	Upper North Santiam River	71,406	21,892	30.7%
1709000504	Middle North Santiam River	56,684	30,283	53.4%
1709000505	Little North Santiam River	72,405	68,103	94.1%
1709000506	Lower North Santiam River	72,785	5,866	8.1%
1709000702	Mill Creek	71,870	686	1.0%
1709000901	Abiqua Creek-Pudding River	179,192	11,212	6.3%
1709000902	Butte Creek-Pudding River	70,441	13,957	19.8%
1709000903	Rock Creek	54,819	47	0.1%
1709000904	Upper Molalla River	129,537	38,588	29.8%
1709001101	Collawash River	97,472	606	0.6%

Table 3. Road Miles by Ownership Designation within Fire Perimeter

Owner Designation	Miles[a]
Bureau of Land Management	230.6
County Route	60.9
Forest Service	126.5
Municipal Route (urban, residential, etc.)	0.3
Other State Route (e.g., State Park)	0.2
Private Route	86.0
ODF State Forestry Route	33.6

Table 4. Miles of Stream within Fire Perimeter by Type

Stream Type	Miles by Type[b]
Perennial	598
Intermittent	1,010
Ephemeral	0
Other	72

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 Beachie 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 6).

Table 6. 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	19,968	10%	14,711	8%	0	<1%	4,310	2%	946	<1%
Moderate	100,920	52%	45,720	24%	151	<1%	45,158	23%	9,891	5%
Low	63,280	33%	25,479	13%	77	<1%	26,768	14%	10,957	6%
Unburned	8,463	5%	4,147	2%	0	<1%	2,067	1%	2,249	1%
Total	**192,631**		**90,057**		**228**		**78,303**		**24,043**	

The areas of high SBS occurred primarily in the higher elevations on ridgelines and peaks. Lower elevations and riparian areas were observed as being unburned or low SBS due to the heterogeneity of vegetation and soil moisture content. Moderate and high SBS was consistently observed on south facing slopes, such as the south facing slope of Elkhorn Mountain on Beachie Creek. South facing slopes are generally drier and therefore ground fuels were less resistant to fire.

1.2.2. WATER-REPELLENT SOIL (ACRES)

Not quantified. 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.

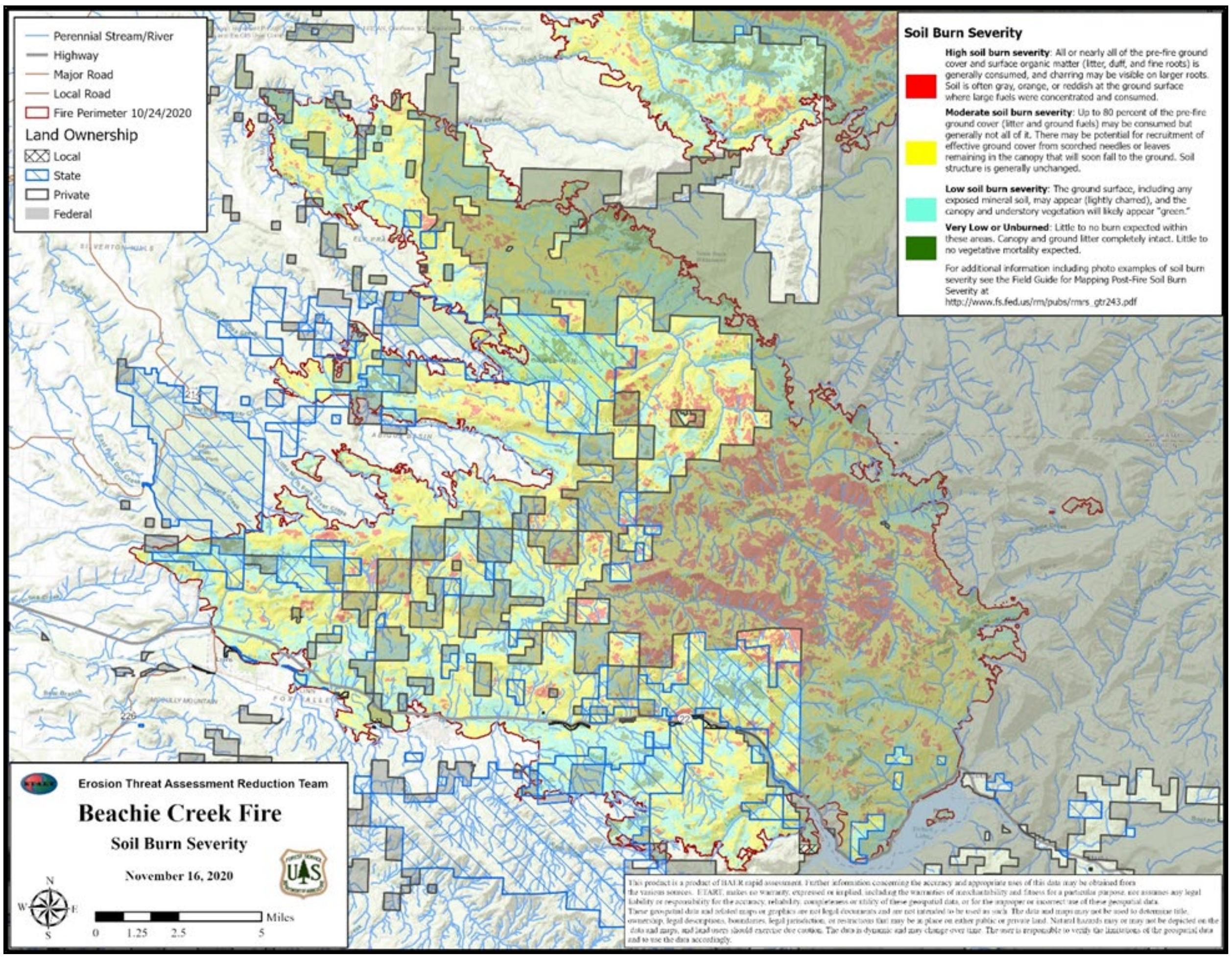


Figure 3. Soil Burn Severity – Beachie Creek Fire

Figure 4 displays the spatial distribution and acres by SEI for the area burned by Beachie Creek Fire. The matrix values in the map table represent combinations of inherent SEI with SBS. The analysis estimates 85% 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.

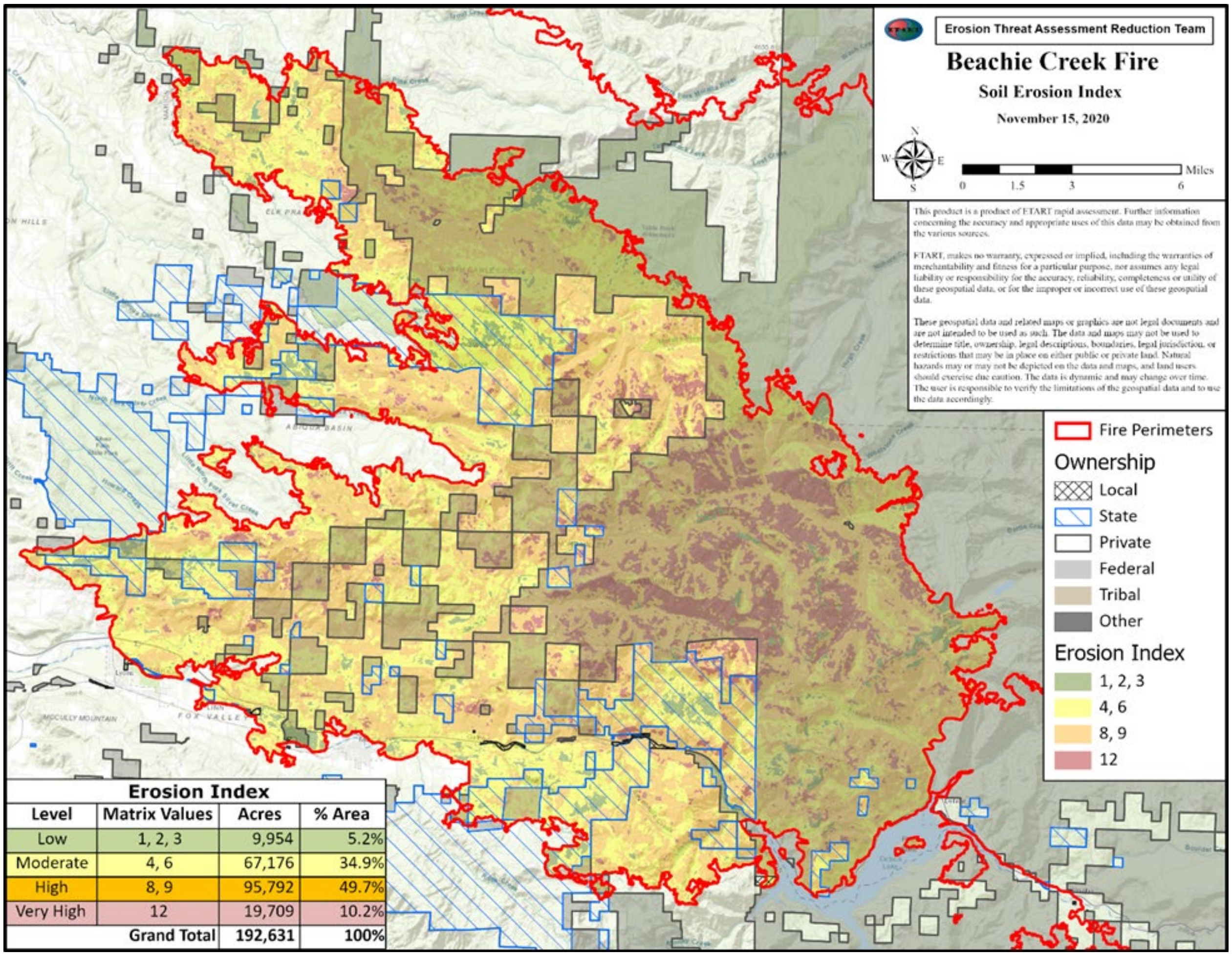


Figure 4. Soil Erosion Index – Beachie Creek Fire

1.2.4. EROSION POTENTIAL

This analysis is used to identify 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 45 drainages across 12 subwatersheds (HUC12) were evaluated. Each drainage was modeled for post-fire response using the SBS data and compared to unburned conditions. The estimated soil loss per watershed unit area ranges from no change up to 4 tons/acre the first year after the fire, averaging about 2 tons/acre across the burned watershed of interest. On average this equates to roughly a 6-times increase in potential soil erosion post-fire over undisturbed conditions.

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.

1.2.6. ESTIMATED HYDROLOGIC RESPONSE

Regional regression equations were used to estimate pre- and post-fire peak flows. Relative increase in 5-year post-fire peak flows is expected to be largest in the Little North Fork Santiam watershed where over 94% of the watershed burned. The Little North Fork Santiam River at Salmon Falls has a predicted increase in peak flow of 1.6 times the pre-fire peak flow magnitude. The elevated peak flow response is due to the large portion of moderate or SBS in a relatively smaller watershed. In contrast, the greatest increase in magnitude of post-fire peak flows in any other subwatershed is 1.2 times the pre-fire peak flow for the 5-year recurrence interval (Figure 5).

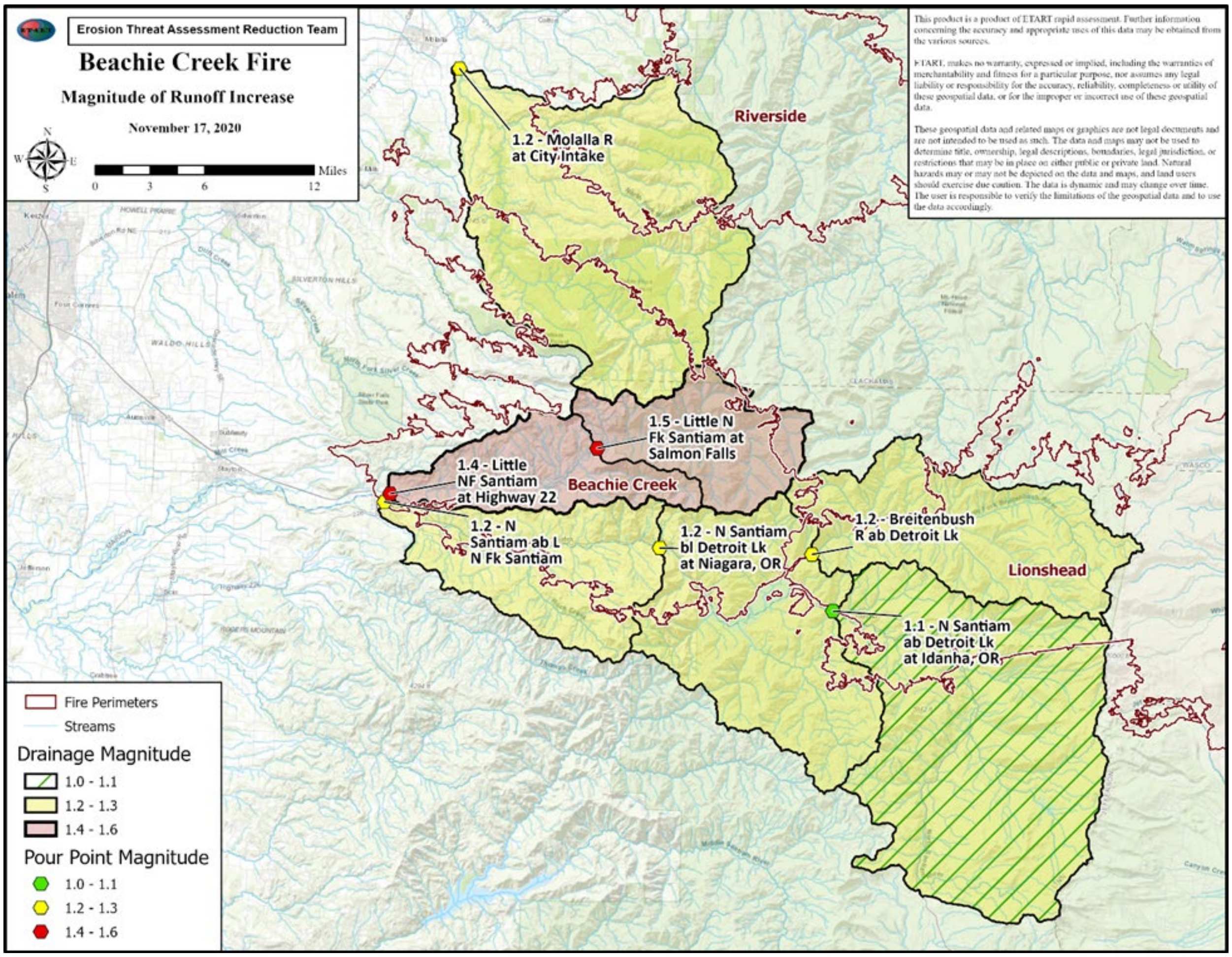


Figure 5. Watershed Response in Runoff Magnitude Increase – Beachie Creek Fire

For areas within the Middle North Santiam River watershed, the regional regression equations do not factor in alterations to hydrology due to Detroit Lake and Big Cliff Reservoir operations. The largest tributary within this watershed, Rock Creek, remained largely unburned. Burned areas within the watershed include smaller tributaries such as Mad Creek and Sevenmile Creek, as well as the smaller, steep northern slopes draining into the middle portion of the North Santiam River. Although the magnitude of peak flows for streams within burned areas are projected to increase, the North Santiam River below Detroit Lake and Big Cliff Reservoir are designed to handle scheduled releases of much greater magnitude. Risk associated with burned areas downstream of the reservoir system in the Middle North Santiam River watershed are likely to be minimal along the main stem of the North Santiam River.

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.

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 Beachie 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). With respect to travel routes, of the roughly 1,050 of assessed miles on state, county and non-industrial private land (including unspecified private), an estimated 220 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. There are over 1,200 acres of hazard trees within a 100-foot buffer surrounding 1,490 structures. There are 744 structures in areas that suffered 50% or greater basal area mortality. Another 746 structures are located in areas that suffered less than 50% basal area mortality. Specific areas of concern noted by the ETART include all Marion County roads, Marion county parks (Salmon Falls Park, Packsaddle Park, Bear Creek County Park and Campground), Santiam State Forest, and North Santiam State Recreation area.

Low risk (possible, minor) to **visitors and employees in Niagara Park, Packsaddle Park, Minto County Park and other public parks and river access** areas from hazard trees near and upslope of park areas and along river access trails.

Recommendations: 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 in the Elkhorn Valley and along OR-22** from debris flows. Numerous facilities and structures located on debris flow and SLIDO mapped fan deposits.

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.

Very High risk to **employees and public at North Fork Park, people traveling North Fork Road SE, and people traveling OR-22 corridor** from rock fall and rolling debris. High SBS area has destabilized slopes increasing threats for loosened rock and debris roll-out. Specific locations of concern are North Fork Park (44 48'N, 122 34'W), North Fork Road SE (44 48'N, 122; 33'W and 44 48'N, 122 28'W), and along the OR-22 corridor. OR-22 has little to no shoulder in some locations and poor sight distance that presents the possibility for injury. If users are struck by, or attempt to circumvent fallen debris, it may result in injury or death.

Recommendation: Blast boulder above North Fork Park and remove hazard trees. Use scalers to pry and drop loose rock above North Fork Road SE and remove hazard trees. OR-22 should receive road and ditch line maintenance and storm patrol to maintain water flow efficiency throughout the winter, hazard warning signs, and monitoring as additional treatments may be necessary.

High risk to **life and safety at Detroit, Niagara, Gates, Mill City, Mahama, Cascades Sport Camp and Detroit Lake State Recreation Area** from debris flows, rock fall or landslides. Portions of the communities and/or facilities are built on past debris flow fan deposits.

Recommendations: 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.

Intermediate risk to **life and safety at Salmon Falls and North Fork County Parks** from debris flows, rock fall or landslides.

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 Sardine Creek and Mayflower Creek at OR-22 and Big Cliff Reservoir** and **the Elkhorn Golf Course** from debris flows, rock fall or landslides.

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

Very Low risk to **life and safety at Bear Creek County Park, Idanha, Packsaddle County Park, and Elkhorn Woods Park** from debris flows, rock fall or landslides.

Recommendation: Property owners should be alerted of potential debris flow and flooding threats. 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.

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

Very High risk to **boaters on Detroit Lake, North Santiam and Little North Santiam** from floating woody debris. High tree mortality will contribute to increased woody debris that could result in injury or death while boating.

Recommendations: Signage at boat docks/marinas, removal of woody debris. Inform county Emergency Management, Oregon Marine Board and boating groups.

Low risk to v**isitors and employees at Kimmel city park and John Neal Memorial Park** from elevated post-fire flooding. There is abundant woody debris in channel but the drainage is downstream of reservoir and receives regulated flow.

Recommendations: Hazard warning signs and debris removal.

2.2. Property Summary

Very High risk to **west bound lane of North Fork Road** from fire-killed and wind thrown trees. Road is minor collector for residents and heavily used recreation corridor. North Fork Road SE, 44 50'N, 122 21'W (east of Evans Mountain Rd Intersection). See Appendix A for Road Treatment Cost Estimates.

Recommendations: Remove stumps and repair road surface.

Very High risk to **OR-22** from debris flows. Further evaluation is needed to define site-specific threats to values and identify appropriate mitigations. Risk from debris flow varies by location. ODOT assessing rock fall hazards and debris flow potential (per Stuart Albright, ODOT engineer, 10/27/20).

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

Very High risk to **property and infrastructure at Big Cliff Dam and the "Bear Trap" landslide** from debris flows, rock fall or landslides. Further evaluation is needed to fully define site-specific threats to values and identify appropriate mitigations.

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.

Very High and High risk was found for **Marion County roads including several road-stream crossings along Central Road SE and North Fork Road SE** from debris flow and plugging potential causing culvert failure. Nine culverts on North Fork road burned and were replaced as soon as possible after access was allowed. These culverts will be monitored with all the other culverts in Marion County's road system in the burned area. Four areas were identified as having a high likelihood of debris flow intersecting the road. These crossings have metal pipes and survived the fire but need hydraulic analyses to see if culvert replacement and upsizing is warranted. One culvert has evidence of being undersized for pre-burn conditions noted by scour above the top of inlet and a sizable plunge pool at the outlet. There is the possibility that all crossings need upsized culverts. Central Rd SE had an emergency culvert replacement in the town of Gates. Subsequent consulting engineer's analysis has shown that the new culvert is undersized for post burn flows and will need to be up-sized. See Appendix A for Road Treatment Cost Estimates.

Recommendations:

- North Fork Road SE, Gates-Hill Road SE, Wagner Road SE, and Central ST SE - Maintain road drainage and storm patrol to maintain water flow efficiency throughout the winter.
- Central Road SE (44 45' N, 122 25'W) - Install culvert with appropriate capacity as detailed in consulting engineer's report.
- North Fork Road SE and Keil Creek (44 48'N, 122 31'W) - Monitor during storm events, stage equipment for debris removal.

- North Fork Road SE (44 48'N, 122 32'W) - Install larger culvert and possibly an additional overflow culvert.
- North Fork Road SE (44 50'N, 122 21'W) - Replace two existing culverts with higher capacity water crossing.
- North Fork Road SE (44 48'N, 122 32'W) - Install larger culvert and remove old culvert in old road location ~60' downstream.
- North Fork Road SE (44 50'N, 122 21'W) - Replace two existing culverts with higher capacity water crossing.
- North Fork Road SE (44 48'N, 122 34'W) - Clean floatable debris from inlet and upstream of culvert, monitor during storm events.

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.
- Rolling Dips. Install rolling dips where they will be most efficient and necessary. Rolling dips should be constructed along straight tangents of the road, especially around cross drainpipes to aid in drainage. Critical dips should be installed on the down slope side of cross drain culverts and left in place at locations where culvert failure is possible or likely. Rolling dips route water from the road surface that can cause template erosion and create travel hazards.
- 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 Beachie Creek Fire Engineering Report.

High risk (likely, moderate) to **surface/pavement damage on Gates Hill Road SE** from sluffing of foreslope now destabilized by burned roots, stumps, and incorporated fill debris. Local road is a major connecter for Highway 22 and North Fork Road. Slump starts at 10 feet from EOP and now has a soil tension crack at 8 feet from EOP. Gates-Hill Road SE, 44 47'N, 122 25'W.

Recommendations: Excavate foreslope past tension crack, including stump and root cavities and fill with rock. See Appendix A for Road Treatment Cost Estimates.

High risk to **property and facilities at Detroit, Niagara, Gates, Mill City, Mahama, Cascades Sport Camp, Minto Fish Hatchery, and Detroit Lake State Recreation Area** from debris flows, rock fall or landslides. Portions of the communities and/or facilities are built on past debris flow fan deposits.

Recommendations: 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. 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 **water intakes and facilities for Mollala City and Detroit Lake State Recreation Area** from increased peak flows and deposition of gravel and fine sediment. Analysis indicates post-fire peak flows combined with reduced ground cover are likely to result in accelerated erosion and sediment delivery downstream. The Mollala City water system includes about a 3-day reserve if intake shut down is needed during high water.

Recommendations: For protection of water intakes, increase frequency of inspection and debris removal, and outreach to the public on water usage should the increased loading of sediment and debris require a temporary shutdown. For the drinking water infrastructure at Detroit Lake State Recreation Area, replace damaged infrastructure and clear outlet prior to and after storms. Increase awareness by informing stakeholders and private landowners of potential threats and recommended mitigations.

Intermediate risk to **two road crossings on North Fork Road SE** from debris plugging culverts. Road is major collector for residents and heavily used recreation corridor. Increased post-fire flows from moderate SBS in source area could mobilize existing debris, potentially deliver additional debris. North Fork Road SE,44 48'N, 122 34'W and North Fork Road SE, 44 48'N, 122 32'W.

Recommendations: Remove hazard trees, clean debris from ditches and monitor during storm events. See Appendix A for Road Treatment Cost Estimates.

Intermediate risk to **OR-22 highway corridor and associated infrastructure, including transmission lines, roads and trails within the Santiam State Forest, and the Minto Fish Hatchery infrastructure** from sediment and debris deposition into ditch lines and on to roads. Steep slopes and low post-fire ground cover increase potential for sediment mobilization, in possibly substantial amounts, at some locations. OR-22 is a heavily used access route and substantial damage would result in temporary loss of use. Falling debris is present along access routes to the Santiam State Forest, which may result in isolated damage along road and trail infrastructure. Minto Fish Hatchery infrastructure damage with impacts to water quality could result in decrease in fish rearing capacity. Visual assessment because of limited access to federal fish hatchery.

Recommendations:

- OR-22 - Maintain road and trail drainage and storm patrol to maintain water flow efficiency throughout the winter. Hazard warning signs.
- Santiam State Forest - Maintain road and trail drainage and storm patrol to maintain water flow efficiency throughout the winter. Hazard warning signs. There are 60 to 80 locations that require some level of road repair: cut-slope ravel and ditch cleaning, burned fill-slope material and road shoulder repair, and general sweeping/clearing of woody debris that has blown down in or adjacent to ditches. There are approximately 70 existing stream crossings and cross drain culverts (polyethylene) that need replaced or repaired. These culverts are not currently fully functioning, are blocked, burned, or have a high probability of not functioning due potential for increased sediment delivery. The culverts will need to be prioritized for replacement and repairs based on threat assessments and the needs of the State Forest division. See Appendix A for Road Treatment Cost Estimates.

- Minto Fish Hatchery - Implement water quality monitoring; assess operations due to post-fire water quality concerns.

Intermediate risk to **infrastructure at Bear Creek County Park and Campground** (along Little N Fork Santiam) from hazard trees. Infrastructure includes 3 CXTs (outhouses), pump house and water system, and picnic facilities. Analysis indicates moderate numbers of tree mortality.

Recommendations: Remove hazard trees.

Intermediate risk to **private property and infrastructure along North Fork road, along South Butte Creek road, below Stout Creek outlet (Mehama), Niagara and Mill City** from sediment-bulked flows impacting river banks and surface erosion of property. Threats from hillslope erosion and channel-driven impacts to privately-owned unburned infrastructure.

Recommendations: Inform stakeholders and private landowners of risks and advise on threat mitigation recommendations (e.g. engineering teams to inspect culverts and other road infrastructure) and storm alert systems. Complete site-specific risk assessments. Install hazard warning signs communicating post-fire threats. 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.

Intermediate risk to **property at Salmon Falls and North Fork County Parks, Betty Jane Deardorff Reservoir, Detroit Dam, Or-22/Blowout Road community, and along North Fork and Taylor Park Roads** from debris flows, rock fall or landslides.

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 **roads within Clackamas County, including Copper Creek ML,** from increased runoff, erosion, and debris flows. There are multiple ditch relief culverts along the 3.2 miles of Copper Creek ML at risk of plugging and failing, resulting in road surface erosion, property loss and natural resource damage from increased sedimentation to the watersheds. Three of the four perennial stream crossings along Copper Creek ML are at risk to damage or loss from expected increase in flows.

Recommendations: Maintain road drainage and storm patrol to maintain water flow efficiency throughout the winter. One consideration for the perennial stream crossings is to pull/remove the culverts and provide temporary harden crossings until the watershed response. Otherwise, new culverts can be sized and installed if and when needed. Increased capacity culverts will allow the drainage to establish a post fire flow path, reducing the risk for increased sediment and debris to damage the crossing with accumulated impacts to the watershed below. See Appendix A for Road Treatment Cost Estimates.

Low risk to **bridge across Gates Creek** from woody debris accumulations. Bridge is large span with limited burn area upstream, likely limited potential for debris build-up to compromise structure.

Recommendations: Monitor for debris build up. See Appendix A for Road Treatment Cost Estimates.

Low risk to **infrastructure at Niagara Park, Packsaddle Park, Minto County Park, Salmon Falls Park, and other public parks** from hazard trees and flooding. Post-fire peak flows can damage trail routes; potential for damage to infrastructure (such as CXTs) from hazard trees.

Recommendations: Hazard tree removal, site assessment and inspection and maintenance.

Low risk to **infrastructure at Detroit Lake marina** from floatable woody debris. Increased loading of large wood is likely to create nuisance build-up of debris potentially damaging or blocking access to docks. Facilities appear to be well above river channel, so probably an issue when reservoir levels create slack water.

Recommendations: Increase frequency of inspection and debris removal.

Low risk to **water intake at Salmon Falls Park** from sediment and large wood deposition. Increased peak flows, sediment delivery and woody debris can clog grated intake. While intake is protected by robust grated structure, expected increase in peak flows delivering sediment and woody debris can obstruct water system over time.

Recommendations: Increase inspections and remove debris as needed.

Low risk to **storage capacity of Big Cliff reservoir** because of increases in sediment, gravel and debris delivered by post-fire runoff. Post-fire conditions are expected to increase existing concerns for two small tributary drainages that are current sources for gravel.

Recommendations: Increase inspections for sediment sources after precipitation events. Increase the frequency of gravel removal.

Low risk to **property at Sardine Creek and Mayflower Creek at OR-22 and Big Cliff Reservoir, transmission lines along the North Fork Road and OR-22, and the Elkhorn Golf Course** from debris flows, rock fall or landslides.

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.

Very Low risk (unlikely, minor) to **infrastructure at Detroit Lake State Recreation Area** from floatable woody debris. Increased delivery of large wood is likely to create nuisance build-up of debris potentially damaging or blocking access to docks. Facilities appear to be well above river channel, so probably an issue when reservoir levels create slack water.

Recommendations: Increase frequency of inspection and debris removal.

2.3. Soil and Water Summary

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.

2.4. Fish and Wildlife Habitat Summary

Very High risk to **T&E fisheries habitat** from water quality impairments (temperature) and from contaminants from burned debris. Loss of riparian shading will lead 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. Runoff from urban areas (communities between Lyons and Detroit) 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: Natural regeneration and/or reforestation with mixed hardwood conifer. Work with partners to encourage natural regeneration and/or reforestation with mixed hardwood conifer. Prioritize hazardous waste removal in proximity to waterways. Work with partners to identify prioritize hazardous waste removal in proximity to waterways.

Low risk to **T&E fisheries habitat** from water quality impairments (turbidity) and to **T&E habitat spawning, rearing and refugia habitat access** for ESA-listed species. 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. 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.

2.4.1. GENERAL FISH AND WILDLIFE RECOMMENDATIONS

Maintain or Restore Connectivity. Given the scale of fires and the number of culverts on the landscape, and findings of the ETART Engineering Analysis, 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. The recommendations are to: implement aquatic organism passage options at culvert blockages or when replacing culverts; work with partners to identify priorities and options for fish passage at stream crossing.

Invasive plant control - Shotgun Creek Area. Natural meadows adjacent to private land have a high potential for introduction of invasive plant species. Limiting expansion of invasive species will return substantial benefits for natural meadow habitats in this area. Adjacency to private land, road density and early successional habitat creates conditions for invasive plants to occupy burned areas. The recommendation is to work with partners to prioritize invasive species EDRR and implement motor vehicle access restrictions. Also refer to the 2020 ETART Beachie Creek Fire Botany Report.

Large Woody Debris (LWD). Many of the rivers and streams have historically low levels of LWD. Maintain standing or dead trees within the riparian 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. The recommendation is to work with partners to encourage salvage logging practices that retain LWD, to the extent practicable, for recruitment into stream channels. Locations are variable depending on extent of post-fire salvage logging within riparian zone.

Riparian Shade. 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. The recommendation is to 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.

Keystone species. Allowing for some proportion of riparian areas to regenerate with hardwoods 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). The recommendation is to work with partners to identify alternate artificial revegetation and/or natural regeneration practices for long-term beaver habitat. Locations are variable depending on management goals.

Sensitive Species Area near Gawley Creek. Sensitive species habitats are a priority due to low road and trail densities, which reduce overall disturbance. Promote natural revegetation and minimize post-fire disturbances. The sensitive species benefit from standing dead wood and patchy openings created by the fire. The recommendation is to work with partners to encourage passive restoration to the extent practicable.

Biodiversity Hotspot - Table Rock Wilderness (BLM). Multiple sensitive species in high SBS area. Being wilderness, allow for natural revegetation and minimize post-fire disturbance. High priority due to low road and trail densities, which reduce overall disturbance. This area experienced high basal area vegetation mortality; natural regeneration will take many years. The recommendation is to work with partners to encourage passive restoration to the extent practicable.

Sensitive Species Area - Copper Creek. Sensitive amphibian species in this area that may be impacted by post-fire events. Habitat sensitive species with limited mobility has been impacted by small landslides or slumps, now greater potential for slope failures because of moderate to high SBS. The recommendation is to work with partners on alternatives to stabilize slopes and protect remaining habitat; monitor for species presence.

Biodiversity Hotspot - Bear Creek. Multiple sensitive species in this area that experienced low to moderate SBS. Promote natural revegetation and retention of standing dead wood and woody debris left on the ground. Patchy moderate burn interspersed with low burn severity creates favorable habitat conditions for sensitive species in this area. The recommendation is to work with partners to encourage passive restoration to the extent practicable.

2.5. Native Plant Communities Summary

Very High risk to **native plant communities and wildlife habitat** from new invasive plants and/or spread of established local weed populations introduced by fire suppression activities. Exposed soils are highly susceptible to introduction of invasive plant seeds transported during fire suppression operations. New infestations can result in considerable long-term effects to surrounding native plant communities. Soil disturbance from suppression activities includes 41.1 miles of dozer line, hand line, road completed line and 12 drop points.

> Recommendations: Early Detection, Rapid Response (EDRR) to survey and control priority weeds and invasive plant species in areas of fire suppression activity. Seed disturbed areas with native Blue Wild Rye seed mix; monitor 3 to 5 years to identify if additional treatments are needed.

Very High risk to **native plant communities in Little Sweden restoration area** from introduction of new invasive plants and/or spread of established local weed populations. There is an increased threat to past and planned habitat restoration activities in areas burned at high to moderate SBS that are highly susceptible to nearby known invasive plant populations. Little Sweden lands are managed by the Confederated Tribes of Warm Springs, who have conducted past restoration activities and have future restoration activities planned. Targeting potential invasive plant invasions will protect this investment

> Recommendations: Early Detection, Rapid Response (EDRR) to survey and control priority weeds and invasive plant species. Seeding or planting in high SBS areas

Very High risk to **old growth habitats and native plant communities in Silver Falls State Park** from new invasive plants and/or spread of established local weed populations introduced by fire suppression activities. Soils disturbed by dozer lines are highly susceptible to introduction of invasive plant seeds transported during fire suppression operations. New infestations can result in considerable long-term effects to old growth habitats and native plant communities in the park. Recreational activities often contribute to spread and introduction of invasive plants.

Recommendations: Early Detection, Rapid Response (EDRR) to survey and control priority weeds and invasive plant species along trails and riparian areas. Monitor for spread away from trails; if possible, for longer term treatment needs. Install boot brush stations at trail heads.

Very High risk to **native plant communities in riparian areas along the North Santiam and Molalla River and in tributary drainages** from new invasive plants and/or spread of established local weed populations. Several known invasive plant species occur along riparian corridors, on adjacent private lands. False brome is a significant threat to considerable long-term effects to surrounding native plant communities. Low to high SBS across a large area which may be slow to recover, allowing invasive plants to establish and contributing to increased erosion and more susceptible bare ground for invasive plants.

Recommendations: Early Detection, Rapid Response (EDRR) to survey and control priority weeds and invasive plant species in riparian areas. Monitor for longer term treatment needs. Seeding or planting in high SBS areas.

Very High risk to **native plant communities within the ODFW Little North Fork Conservation Opportunity Area** from new invasive plants and/or spread of established local weed populations. ODFW Conservation Opportunity Area is located in the Little North Fork drainage, with known invasive plants along river corridor in riparian areas and on adjacent private lands. False brome is a significant threat to considerable long-term effects to surrounding native plant communities. Low to high SBS across a large area which may be slow to recover. Area is popular for recreation and provides access deep into the fire area onto federal lands and private timber lands.

Recommendations: Early Detection, Rapid Response (EDRR) to survey and control priority weeds and invasive plant species in riparian areas and long roads. Seeding or planting in high SBS areas with longer term monitoring for future treatments. Weed wash stations.

Very High risk to **old growth habitats in the North Santiam State Recreation Area** from introduction of new invasive plants and/or spread of established local weed populations. Expansion of several known invasive plant species that occur along riparian corridors and on adjacent private lands could result in considerable long-term effects to surrounding native plant communities. False brome is a significant threat to investments from past and planned habitat restoration activities in the North

Santiam State Recreation Area restoration investments after 2019 wildfire. High recreational use will contribute to spread and introduction of invasive plants.

Recommendations: Early Detection, Rapid Response (EDRR) to survey and control priority weeds and invasive plant species along trails and riparian areas. Monitor for spread away from trails. Install boot brush stations at trail heads.

High risk to **native plant communities and wildlife habitat in ODFW Habitat Conservation Plan Areas** from introduction of new invasive plants and/or spread of established local weed populations. Moderate SBS areas immediately adjacent to known invasive plant locations can result in considerable long-term effects to surrounding native plant communities and wildlife habitat.

Recommendations: Early Detection, Rapid Response (EDRR) to survey and control priority weeds and invasive plant species in proposed ODF Habitat Conservation Plan Areas.

High risk to **native plant communities within and adjacent to the Oregon Watershed Restoration Inventory project areas** from introduction of new invasive plants and/or spread of established local weed populations. Moderate SBS areas susceptible to invasive plants, threaten investments in past restoration efforts to prevent establishment of invasive plants and can result in considerable long-term effects to surrounding native plant communities.

Recommendations: Early Detection, Rapid Response (EDRR) to survey and control priority weeds and invasive plant species in proposed ODF Habitat Conservation Plan Areas.

High risk to **oak habitats** from introduction of new invasive plants and/or spread of established local weed populations. Oak habitats are considered a "Strategy Habitat" in the Oregon Conservation Strategy and are in decline. Invasive plants are a threat to the understory and to re-generation of new oak seedlings. Moderate SBS areas immediately adjacent to known invasive plant locations can result in considerable long-term effects to surrounding native plant communities.

Recommendations: Early Detection, Rapid Response (EDRR) to survey and control priority weeds and invasive plant species in proposed ODF Habitat Conservation Plan Areas.

High risk to **wetland habitats** from introduction of new invasive plants and/or spread of established local weed populations. Wetland habitats are considered a "Strategy Habitat" in the Oregon

Conservation Strategy, habitats include marshes, bogs and emergent wetlands; lowland woody wetlands and swamps. Extensive existing invasive plant populations are likely to expand to burned ground, with increased potential where loss of canopy cover may alter species composition and result in long-term effects to wetland habitats.

Recommendations: Early Detection, Rapid Response (EDRR) to survey and control priority weeds and invasive plant species.

High risk to **montane grassland and meadow habitats** from introduction of new invasive plants and/or spread of established local weed populations. Grassland habitats are considered a "Strategy Habitat" in the Oregon Conservation Strategy. One location of this habitat type is within the fire area on ODF property near Niagara, which may be located near trail access that could increase potential to introduce new invasive plants.

Recommendations: Early Detection, Rapid Response (EDRR) to survey and control priority weeds and invasive plant species.

Intermediate risk to **native plant communities in Marion County Parks** from expansion or introduction of invasive plant species. Several known invasive plant species occur along riparian corridors, on adjacent private lands and in some county parks. Low to moderate SBS in these areas contribute to expansion of existing infestations. False brome is a significant threat to considerable long-term effects to surrounding native plant communities. Parks experience heavy recreational use and trails are a vector for spread of invasive plants.

Recommendations: Early Detection, Rapid Response (EDRR) to survey and control target weed s and invasive plant species along trails and in parking areas. Monitor for weed spread away from trails. Install boot brush stations Marion County Park trail heads.

Intermediate risk to **native plant communities along North Fork Road and on surrounding properties** from expansion or introduction of invasive plant species. Several populations of known invasive plant species exist along riparian corridors and on adjacent private lands. Riparian areas and lands adjacent to roads with moderate SBS can be occupied by new infestations introduced from equipment and vehicles travelling along the roadway. Spread of False brome is a considerable threat as the North Fork Road is the major access point into many recreation sites on public lands, and access to large areas of industrial timber properties.

Recommendations: Early Detection, Rapid Response (EDRR) to survey and control priority weeds and invasive plant species. Install weed wash station at the North Fork Road and Highway 22 intersection.

Low risk **to habitats supporting historic T&E and rare plants** from introduction of invasive plant species. There are no currently mapped invasive plants near sites, however plants may no longer exist on the sites. Most recent data entry for the fire area was in the 1990's.

Recommendations: Surveys to determine if T&E or rare plants exist and to detect any new invasions of invasive plants.

Low risk to **productivity of private forest land** from the spread of invasive plants into tree plantations along roads and during salvage logging activities. Disturbance from fire and suppression activities resulting in bare soil increases potential for occupancy by weed populations that may spread into valuable habitat areas. Noxious weed species can inhibit tree growth through competition, however timber harvest operations already implement regular weed control efforts.

Recommendations: Install weed wash station near Scotts Mills at intersection of Hwy 22 and North Fork Road.

2.6. 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 effective treatments for 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

Many gaging stations are present in watersheds within and adjacent to the burned areas of the Beachie 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 if practicable, 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. Roads and Travel Routes - Management Recommendations

Rock Fall, Channel Debris and Flood Hazards - For locations where rock fall may occur, the recommendation is for signs to be posted and for thoroughfares to be cleared and maintained regularly. During storm inspection and response, channel clearing of debris that may be mobilized by flooding recommended at and immediately upstream of road crossings. If failure of a road crossing could result in residents being stranded, it's recommended that county emergency managers be made aware and that signs be posted to educate residents.

Storm Inspection and Response - Continue storm inspection and response until vegetation has reestablished in affected watersheds.

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. Large wood in an impoundment like Leaburg Lake can more easily be treated by removing it, but signage is also important to warn boaters of the risks.

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.

Resource Reports

1. Weeds Specialist Report

Jenny Meisel, Marion Soil and Water Conservation District
Rebecca McCoun, North Santiam Watershed Council

1.1. Summary

1.1.1. OBJECTIVES

- Evaluate fire impacts to vegetation resources on state and private lands
- Identify imminent post-wildfire threats and impacts to critical natural resources
- Provide recommendations to manage unacceptable risk caused by invasive plant infestations
- Determine and specify necessary treatments and associated monitoring activities

This assessment and report focus on recommendations for the first-year post fire. However, noxious weeds will be a continuous threat to all burned areas for many years as the native vegetation and soils recover from this catastrophic event. Many noxious weed populations are also not controlled in one year. It is recommended that early detection and rapid response (EDRR) surveys, treatments and monitoring continue for a minimum of 3-5 years.

1.1.2. CRITICAL VALUES

Native or naturalized plant communities on state and private lands where invasive species or noxious weeds are absent or are present in only minor amounts.

1.1.3. THREATS/RISKS

Establishment and expansion of invasive plant species into burned and suppression activity areas. Risks of new infestations, particularly in vulnerable and sensitive habitats where invasive plants are currently absent.

1.1.4. RESOURCE CONDITION AND SETTING

The Beachie Creek Fire was first detected on August 16, 2020 approximately 2 miles south of Jawbone Flats in rugged terrain deep in the Opal Creek Wilderness, located in the Little North Santiam Watershed subbasin. A historic windstorm on Monday, September 7, caused rapid spread west through the Willamette and Mt. Hood National Forests, and adjacent private lands and communities. The unique wind event created an extreme environment in which the fire was able to accelerate. The winds were 50-75 miles per hour, and the fire growth rate was about 2.77 acres per second in areas of the Beachie Creek fire. This allowed the fire to reach over 130,000 acres in one night. The fire grew to 190,000 acres by September 17th and peaked at a total of 193,573 acres (InciWeb).

The Beachie Creek Fire heavily impacted communities in the middle North Santiam subbasin (Lyons/Mehama, Mill City, Gates and Niagara) and in the Little North Fork Santiam subbasin (Elk Horn and Jawbone Flats).

Impacted Subbasins

- The Little North Santiam River Watershed drains a 113 square mile (72,319 acres) area. Forestry accounts for almost all of the land use. Land ownership is dominated by USFS Willamette National Forest lands (50%) and BLM (18%) with the remaining (32%) in private ownership. There is a protected old growth forest and five major tributaries that flow into the Little North Santiam River: Elkhorn Creek, Cedar Creek, Big Creek, Battle Ax Creek and Opal Creek. The Little North Santiam River is a tributary to the North Santiam River, with its confluence located at Lyons (NSWC 2014).
- The Middle North Santiam River Watershed drains an 86 square mile (55,039 acres) area of the Cascade Range and includes Mill City, Gates, Niagara and a portion of the City of Lyons. The area is dominated by private ownership, however, 11% of the watershed is owned by BLM, and land use is primarily forestry. The flow in the North Santiam River is supplemented from Rock Creek, the largest tributary in this watershed. The North Santiam River divides the subbasin with Marion County to the north and Linn County to the south. (NSWC 2014).
- The Upper Molalla River watershed is seven miles southeast of the city of Molalla. The watershed is almost entirely contained within Clackamas County; a very small portion of the headwaters of Copper Creek is in Marion County. The watershed is approximately 129,300 acres (202 square miles) with a high percentage of federal ownership (75%). (BLM 1999).
- A small portion of the Upper Pudding River Watershed including parts of the Abiqua Creek-Pudding River and Butte Creek-Pudding River subbasins was also burned in the fire. The watershed encompasses 528 square miles, much of which is used for farming, timber harvest, manufacturing, and recreation. Land ownership in the burned area consists of industrial timber property mixed with state and federal ownership. (Oregon Explorer).

The fire includes areas on the Detroit Ranger District on the Willamette National Forest and a small portion of the Clackamas River Ranger District on the Mt. Hood National Forest, accounting for ~47% of the total fire area. Vegetation on Federal lands consists of mixed conifer, grass and shrub fields with numerous snags and heavy dead and down fuels. Private and State lands account for ~53% of the total fire area. Within private and state lands, private industrial timber lands have various aged conifer plantations and make up 31.5% of the total acreage in the fire. Other private lands include city properties, small and moderate size home lots to larger acreage non-industrial timber lands which account for ~9% of total land impacted by the fire. State lands impacted by the fire account for ~12% of the total burned area and include popular recreation sites on the Santiam State Forest (Shellburg Falls Recreation Area, Santiam Horse Camp, Rock Creek Campsites, Crooked Finger OHV Area, Butte Creek Falls Trail and Campground, Rhody and Butte Lakes campgrounds) and Oregon Parks and Recreation Department properties (Silver Falls State Park, North Santiam State Recreation Area and Detroit Lake State Recreation Area). Several Marion County Parks are also within the fire perimeter. The fire impacted the entire Little North Fork Santiam River subbasin, a large portion of the middle North Santiam River subbasin and a significant portion of the upper Molalla River Watershed. The Lionshead Fire, which combined with the Beachie Creek Fire burned a large portion of the Upper North Santiam Watershed the Warm Springs Reservation and a portion of the Upper Deschutes Watershed. The Lionshead fire occurred east of the Beachie Creek and the two converged near the town of Detroit, Oregon.

Table 1. Beachie Creek Fire Land Ownership

Ownership	Acres	% of total
Federal	90,031.1	46.8%
Private (Non-Industrial)	17674.3	9.1%
Private (Industrial)	60,580.8	31.5%
State	24,043.8	12.5%
Local Government	228.4	0.1%
Total	**192,558.4***	**100.0**

* number calculated before fire was completely contained

1.2. Assessment Methodology – Field assessment and Modeling

The Beachie Creek fire on state and private lands was assessed using local knowledge of the plant communities and invasive plants in the fire area as documented in survey data and local assessments. Several visits to private properties in the burn area have been made over the past two months. In addition, post burn aerial imagery, extensive mapping exercises and modeling using Geographical Information Systems (GIS) was employed to identify the various ways the fire impacted the landscape.

Modeling Criteria used Natural Vegetation Protection Areas Buffer of 50m, Invasive Species buffer of 50 m, and Vegetation Mortality >50% Basal Area loss. Inputs for the Natural Vegetation Protection Areas included: ODFW (Oregon Department of Fish and Wildlife) Conservation Opportunity Areas, ORBIC (Oregon Biodiversity Information Center) data for rare, threatened and endangered plants, areas where past and current natural resource restoration activities have taken place (OWRI-Oregon Watershed Restoration Inventory, Little Sweden-Confederated Tribes of Warm Springs property), Oregon Parks and Recreation Department properties (North Santiam State Recreation Area and

Silver Falls State Park), Oregon Department of Forestry proposed Habitat Conservation Plan Areas, and sensitive and unique habitats designated by the Oregon Conservation Strategy (meadows, grasslands, wetlands, and oak woodlands). Invasive species data included information from iMap Invasives, WeedMapper, Clackamas Soil and Water Conservation District and Marion Soil and Water Conservation District.

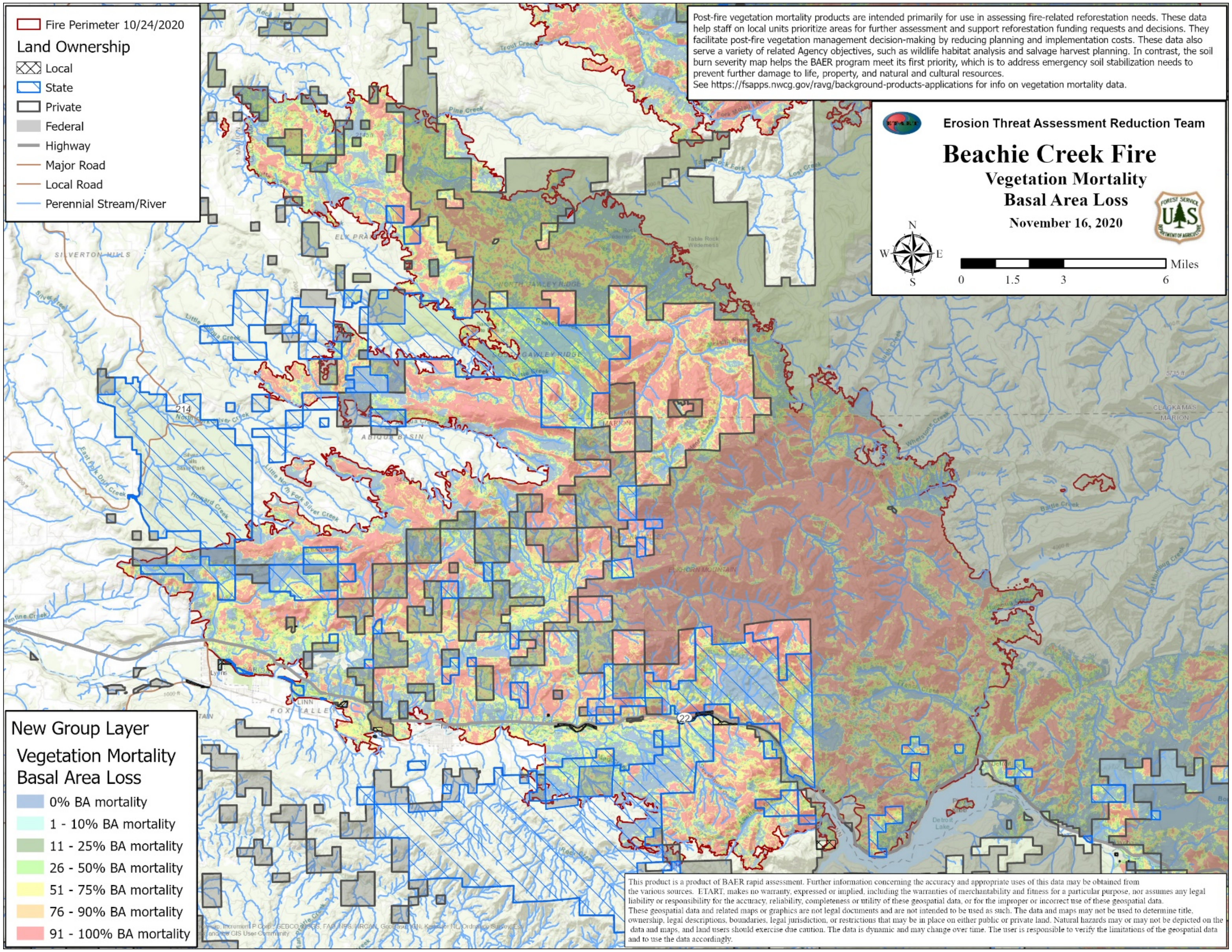
Old growth forests and riparian areas were considered as natural vegetation protection area inputs to the model but were ultimately not included because of the large area that they cover within the fire perimeter. Old growth habitats are most likely protected from weed invasions because of their remoteness and limited access. Surveys and treatments in sensitive old growth habitats may cause further disturbance. The Little North Fork Santiam riparian area was included in this analysis as part of the ODFW Conservation Opportunity Area data set.

1.3. Results

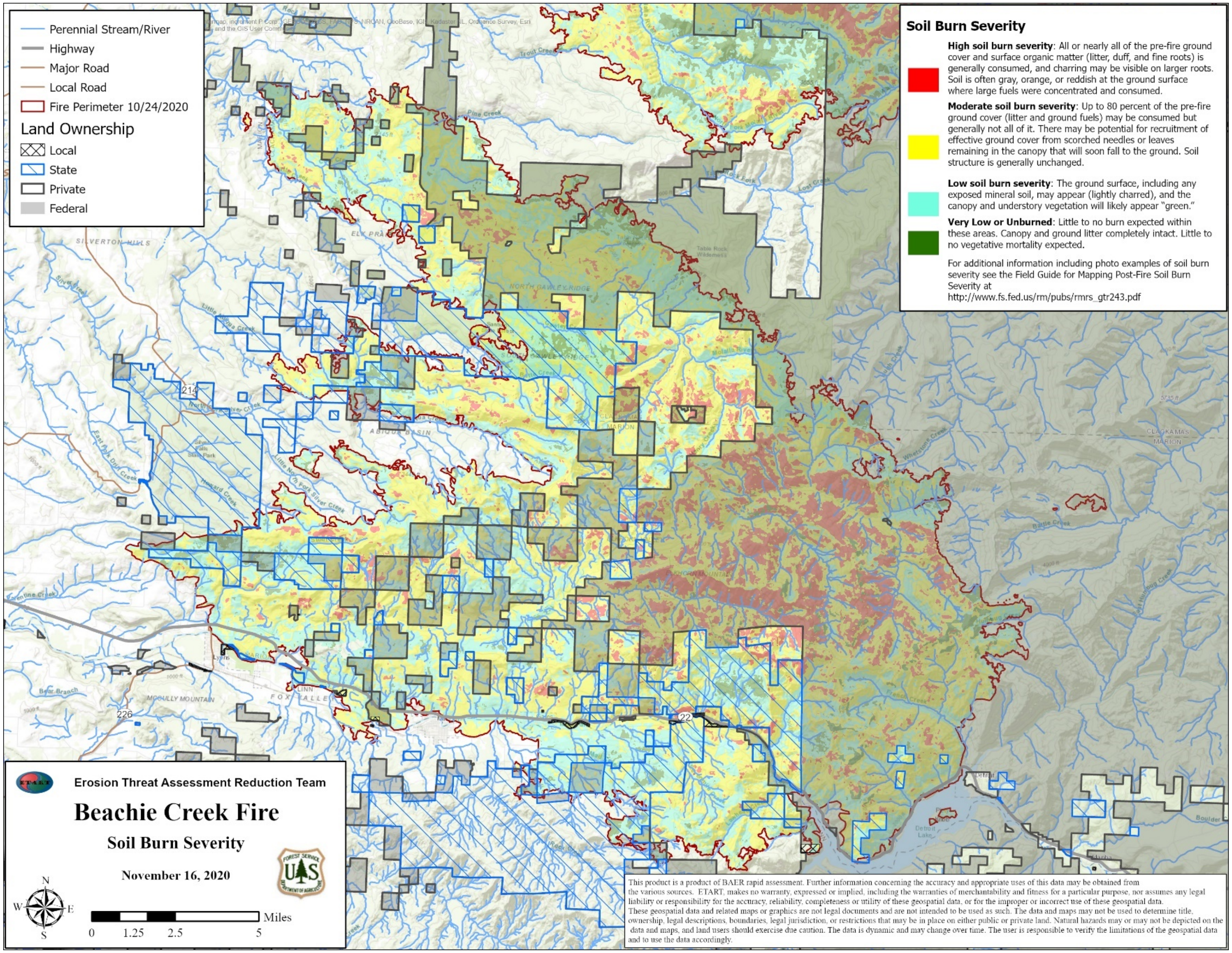
Burned areas on State and Private lands were a mix of high, moderate and low severity (Map 1, Map 2). Almost 60% of private and state lands within the Beachie Creek Fire burned at high and moderate severity. High to moderate soil burn severity and high to moderate vegetation mortality areas within the Beachie Creek Fire area are subject to spread of noxious weed communities and invasive species. The loss of canopy cover and reduction of vegetation by fire and loss of soil productivity produces a favorable environment for invasive plant introduction or plant community conversion. Existing infestations are now seed sources for newly exposed areas. Once introduced, many of the noxious and invasive species have the potential to out compete native plant communities during post fire recovery.

Table 2. Beachie Creek Soil Burn Severity

Burn Severity	Private/State (acres)	Federal Land (acres)
Unburned	4,222.1	4,125.0
Low	37,756.6	25,476.2
Medium	55,200.4	45,719.8
High	5,258.5	14,710.1
Total	**102,527.3**	**90,031.1**



Map 1. Vegetation Mortality - Beachie Creek Fire



Map 2. Soil Burn Severity - Beachie Creek Fire

The Beachie Creek Fire burned area has extensive mapped and unmapped weed populations that have historically persisted along roadways, trails and riparian areas. Species such as false brome, (Brachypodium sylvaticum), Scotch broom (Cytisus scoparius), English ivy (Hedera helix), thistles and Himalayan/Armenian blackberry (Rubus armeniacus) are ubiquitous along many roads and in riparian areas within the burned area. Until now, their spread has been primarily limited to increasing their presence along the road system, along recreation trails and in disturbed areas. However, these species are fire tolerant, opportunistic, and well poised to take advantage of the freshly denuded ground and newly opened canopy that has been exposed by the fire.

A total of 18 species on the Oregon Department of Agriculture's Noxious Weed list have been documented within the fire impacted area, all with a B or B/T ranking. No A-listed species are known to occur within the fire perimeter at the time this report was written. See Appendix B for description of the weed rankings. In order to prioritize treatments and resources, species were separated into 2 categories: EDRR for the entire fire, and EDRR only in natural vegetation protection areas.

Table 3. Invasive Weed Species in Fire Area

Species Name	Common Name	Oregon Dept. of Ag Rank	EDRR species for the Beachie Creek Fire
Allaria petiolata	Garlic Mustard	B/T	Yes
Brachypodium sylvaticum	False Brome	B	Yes
Carduus pycnocephalus	Italian Thistle	B	Yes
Centaurea stoebe	Spotted Knapweed	B/T	Yes
Centaurea diffusa	Diffuse Knapweed	B	Yes
Cantaurea x moncktonii	Meadow Knapweed	B	Yes
Cirsium arvense	Canada Thistle	B	Only in natural protection areas*
Cirsium vulgare	Bull Thistle	B	Only in natural protection areas
Cytisus scoparius	Scotch Broom	B	Only in natural protection areas
Geranium lucidum	Shiny Geranium	B	Only in natural protection areas
Hedera helix	English Ivy	B	Only in natural protection areas
Hypericum perforatum	St. Johnswort	B	Only in natural protection areas
Iris pseudacorus	Yellow Flag Iris	B	Only in natural protection areas
Lamium galeobdolon	Yellow Archangel	B	Yes

Species Name	Common Name	Oregon Dept. of Ag Rank	EDRR species for the Beachie Creek Fire
Lythrum salicaria	Purple Loosestrife	B	Only in natural protection areas
Polygonum and Fallopia spp.	Knotweeds	B	Yes
Rubus armeniacus	Armenian Blackberry	B	Only in natural protection areas
Senecio jacobea	Tansy Ragwort	B/T	Only in natural protection areas

*Natural protection areas were identified in the Geographic Information Systems (GIS) analysis, and do not include the entire burn area

Species of particular concern in the fire area include: False brome (Brachypodium sylvaticum), Italian thistle (Carduus pycnocephalus), spotted, meadow and diffuse knapweed (Centaurea stoebe, moncktonii & diffusa), and garlic mustard (Allaria petiolata).

- False brome has the potential to spread rapidly in areas of low to moderate burn severity, which covers a significant portion of the fire area on state and private lands. Studies have shown that consistent high intensity fire can reduce and even eradicate populations, but that non-uniform fire intensity, specifically low severity fire, contributes greatly to its spread by reducing competitive vegetation. Once it is established, it propagates a self-perpetuating “grass-fire cycle” that alters an ecosystem in a way that increases the likelihood of its own success (Poulos & Roy 2015). It is not rhizomatous, propagating only by seed.

- Garlic Mustard is not known to exist in the fire perimeter but is found in abundance in areas of Clackamas County and other counties arounds the Portland Metro area. There is a high risk of garlic mustard invasion through recreation activities, from firefighting equipment, and from suppression activities.

- Italian Thistle, spotted, and diffuse knapweeds occur in small isolated populations and have the potential to spread into larger populations after the fire.

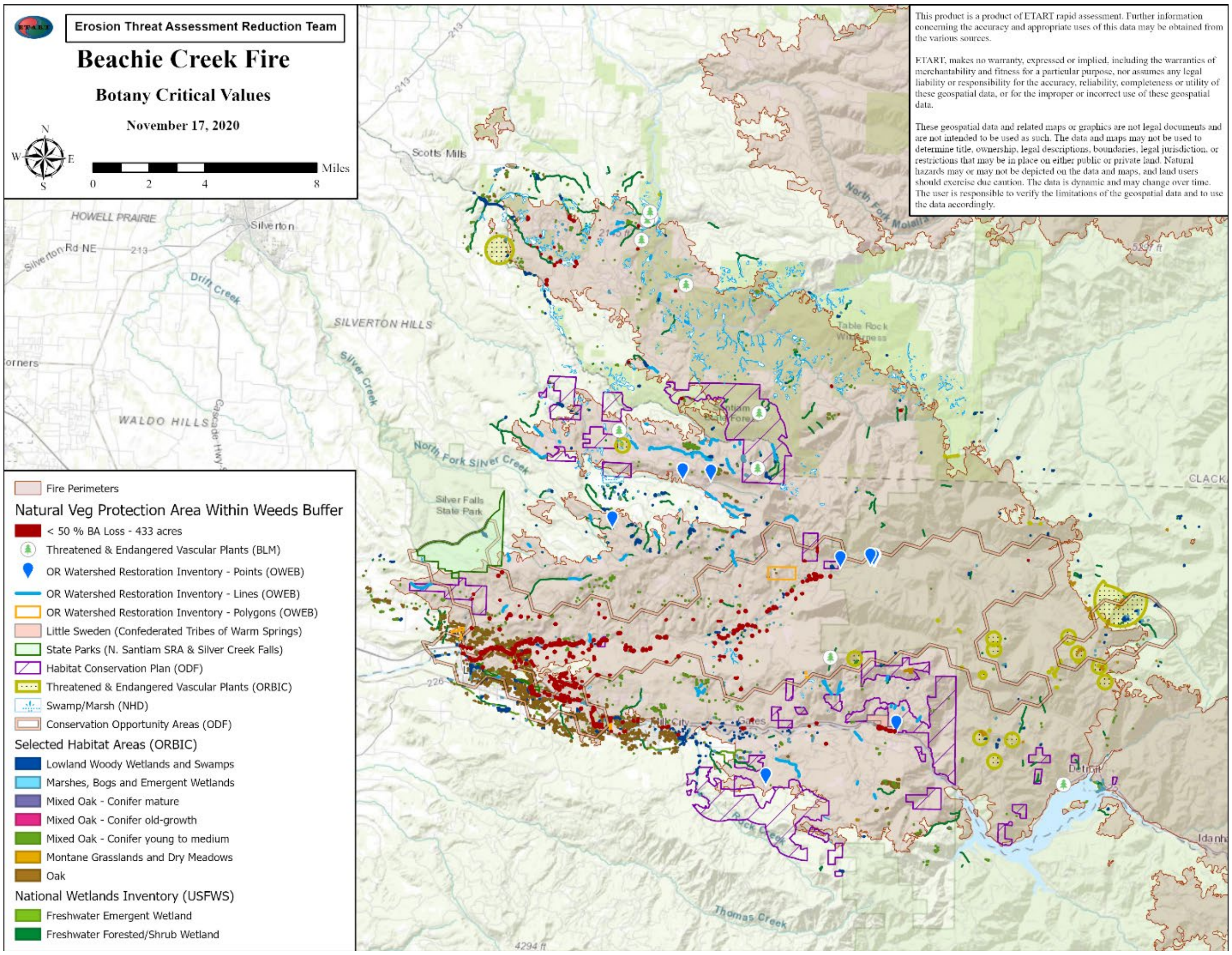
- Meadow knapweed is more common in lower elevations along both the North Santiam River and Little North Fork. Infestations in the fire area should be part of EDRR surveys and treatments to prevent further spread downstream. Working on the populations in this area of the watershed will be a top down approach to control of this species.

Appendix B contains profiles and fire response information for several invasive plants that pose the greatest risk to native plant communities in the Beachie Creek fire area.

Photo 1. Shiny Geranium sprouting extensively after fire

Photo 2. False Brome re-sprouting after fire

Modeling results show that 433 acres of natural vegetation protection areas with native plant communities are within close proximity of known invasive plant infestations and are at a high risk of invasion by invasive plants. These areas are indicated in red on the map below.



Map 3. Natural Vegetation Protection Area Modeling (Indicated in Red)

Suppression activities, such as, dozer and hand lines, roads improved for fire break, helibases, camps, helispots and drop points present a risk of new invasive species introduction. Post-fire operations also pose an additional seed source of noxious weeds. It is well known that vehicles travelling along infested corridors and heavy equipment that has not been properly cleaned can introduce and spread noxious weeds into newly burned or repair areas. It is very likely that non-native invasive plants were transported into and spread within the Beachie Creek fire perimeter. There is a total of 177.2 miles (estimated 291 acres) of completed dozer lines, hand lines and road completed line and 63 suppression points (acres not known) on state and private lands.


Photo 3. & 4. Dozer lines in Silver Falls State Park

1.3.1. ADDITIONAL CONCERNS

Roadways

Oregon (OR) State Highway 22 and the Marion County maintained Little North Fork Rd are both highly traveled roadways. Highway 22 is a major corridor between the Willamette Valley and Central Oregon. Both roads are access points to recreation sites, residential and vacation homes, small towns and industrial timber properties. Fire impacts will result in an increase in use of these roadways as loggers, contractors, electricians, etc. assist with post fire recovery and restoration efforts. North Fork Rd runs approximately 20 miles through moderate soil burn severity along the Little North Fork Santiam River from Hwy 22 to Federal lands. In addition, home structures and outbuildings burned to the ground by the fires heavily impacted the surrounding soil and vegetation in many canyon neighborhoods. With hazard trees removed and understory vegetation destroyed there is the potential for new infestations of invasive plants. The following side roads had multiple homesites destroyed:

Marion County

Jennie Rd, Riverwood Rd, Dogwood Circle, Dogwood Ln, Ruth St, Francis St, Elkhorn Drive, N Santiam Hwy E, Railroad Ave, N.Santiam Hwy, N. Fork Rd, Kubin Rd, Pioneer Ln, Santiam Park Rd SE, Santiam Way SE, Summerhaven, Taylor Park Rd, DeWitt Ln, Sitkum St.

Linn County

Gates Hill Rd E, Linnwood Drive, Greenway Drive, Lyons-Mill City Drive.

Photo 5. Salvaged timber is vulnerable to new weed infestations. Location: Near Little North Fork Rd.

**Photo 6. Burned field of Scotch Broom
Existing seed source along Little North Fork Rd. near MP 13**

Recreational Areas/Trails

Within the Beachie Creek fire there are many popular recreation areas on local, county and state lands that experienced moderate and high burn severity. Many of the recreation sites have known invasive species populations concentrated along areas of high use such as trails and roads. These highly used areas are vectors of spread for invasive plants to invade into previously intact native plant communities.

Photo 7. Shiny Geranium growing along a recreation trail

Photo 8. Burned riparian area vulnerable to weed infestations

Location: Little North Fork Santiam at Elk Horn

Riparian Areas

Burned riparian areas are highly vulnerable corridors for the spread of invasive plant species by high water events, recreationists, and dogs, as well as birds and wildlife that use them for migration corridors. There are 3 significant rivers/watersheds impacted by this fire, Upper Molalla, Little North Fork Santiam and North Santiam. Other invasive species not included in this report may be of particular importance to control in riparian areas such as reed canary grass, teasel, etc.

1.3.2. IMPACTS ON THE LANDSCAPE

Results show that the damage from invasive plant infestations would cause major to moderate consequences to native plant communities with irreversible damage or considerable long-term effects with eventual displacement of native plants for the following reasons:

1. Impacts of soil burn severity decreases soil productivity for native plant communities.
2. Deterioration of habitat and direct competition from invasive plants spreading along suppression lines into previously un-infested areas that inhibit regeneration of native plant species including merchantable timber through the following processes:
    a. Spread of invasive plants into un-infested areas due to conditions created by the fire (removal of competing vegetation cover, loss of shade, early seral conditions).
    b. Direct competition for resources including water, nutrients, above and underground growing space, allelopathy (suppression of growth of a native plant by release of a toxin from a nearby invasive plant), changes in microhabitat, direct suppression and mortality.
    c. Decreases in native plant diversity by reducing habitat for native plant species and wildlife.
    d. Shifts from diverse native plant communities to non-native invasive plant dominance in dry habitats, altered future fire behavior, intensity, extent and season of burning.
3. Invasion of burned areas by non-native invasive plant species could lead to a loss of local native plant populations.

Table 8. Critical Values Table (subset of information showing risk)

Critical Value	Threat to Value	Probability of Damage or Loss	Magnitude of Consequence	Risk
Native Plant Communities adjacent to and impacted by suppression activities	invasion and introduction of invasive plant species	Very Likely	Major	Very High
Native Plant Communities in Little Sweden restoration area	invasion and introduction of invasive plant species	Very Likely	Moderate	Very High
Native plant communities and wildlife habitat in ODF Habitat Conservation Plan Areas	invasion and introduction of invasive plant species	Likely	Moderate	High
Native plant communities within the ODFW Little North Fork Conservation Opportunity Area	several known invasive plant species along riparian corridor and on adjacent private lands	Likely	Major	Very High
Native Plant Communities within and adjacent to the Oregon Watershed Restoration Inventory project areas	invasion and introduction of invasive plant species into past restoration investment areas	Likely	Moderate	High
Oak habitats. Native Plant Communities	invasion and introduction of invasive plant species	Likely	Moderate	High

Critical Value	Threat to Value	Probability of Damage or Loss	Magnitude of Consequence	Risk
wetland habitats. Native Plant Communities	invasion and introduction of invasive plant species	Likely	Moderate	High
montane grassland and meadow habitats. Native Plant Communities	invasion and introduction of invasive plant species	Likely	Moderate	High
North Santiam State Recreation Area: Old growth habitats and native plant communities	invasion and introduction of invasive plant species. several known invasive plant species along riparian corridor and on adjacent private lands	Very Likely	Moderate	Very High
Silver Falls State Park: old growth habitats and native plant communities	invasion and introduction of invasive plant species	Very Likely	Major	Very High
Marion County Parks: native plant communities	invasion and of invasive plant species. several known invasive plant species along riparian corridor and on adjacent private lands	Possible	Moderate	Intermediate

Critical Value	Threat to Value	Probability of Damage or Loss	Magnitude of Consequence	Risk
Native Plant Communities along North Fork Road and on surrounding properties	invasion and introduction of invasive plant species. several known invasive plant species along riparian corridor and on adjacent private lands	Possible	Moderate	Intermediate
Native Plant Communities: historic T&E/rare plant locations	invasion and introduction of invasive plant species; extirpation of any existing species	Possible	Minor	Low
Private industrial forest	Spread of invasive plants into tree plantations along roads and during salvage logging activities.	Likely	Minor	Low
Native plant communities in riparian areas along the North Santiam and Molalla River and drainages	several known invasive plant species along riparian corridor and on adjacent private lands	Likely	Major	Very High

1.4. Recommendations

Several treatment options including Early Detection and Rapid Response (EDRR) were considered for rehabilitation of suppression and burned areas for the Beachie Creek Fire including use of herbicides and biological controls.

Treatment options considered

- Surveying and manual/mechanical/herbicide treatments of roadsides & trails (EDRR)
- Surveying and manual/mechanical/herbicide treatments of natural vegetation protection areas (EDRR)
- Utilization of biological controls to treat noxious weeds
- Surveying and manual/mechanical/herbicide treatments of dozer line, staging & drop sites (Suppression EDRR)
- Re-establishing vegetation on bare ground disturbed during suppression activities as soon as possible
- Using only native, certified weed-free seed mixes when revegetation is necessary
- Applying native blue wildrye seed to dozer lines, staging and drop sites within the fire perimeter (Suppression EDRR)
- Applying native blue wildrye seed and/or native plantings to high severity burn areas where natural vegetation is slow to recover
- Installing boot brush stations at trail heads in high use recreational areas
- Cleaning equipment and vehicles prior to entering the burned area via strategically placed wash stations
- Regulating or preventing human, vehicle and/or livestock entry into burned areas until desirable site vegetation has recovered sufficiently to resist invasion by undesirable vegetation

1.4.1. RECOMMENDED EMERGENCY RESPONSE ACTIONS

The Early Detection Rapid Response (EDRR) recommended treatments are designed to protect sensitive native plant communities and supplement remaining native seed banks that promote native plant community recovery and reduce the potential for invasion of noxious weeds into areas disturbed by fire suppression activities and in all burn severity areas. Preventing invasive plants from establishing in weed-free burned areas is the most effective and least costly management method.

It is critical to perform EDRR actions for invasive plants in the spring and fall of 2021. Treatment is most effective when infestations are small and it is critical to treat the infestations before they can produce seed. EDRR would be used to survey, treat, and monitor invasive plants (noxious weeds) in moderate to high severity burn areas adjacent to existing invasive populations, roads, trails, dozer line, suppression points, staging areas and natural vegetation protection areas identified through GIS modeling and contained in the critical values table. There are approximately 433 acres of prescribed EDRR treatment and surveys recommended in natural vegetation protection areas in the Beachie Creek Fire. In addition to this ~50 miles of trails and roads in moderate severity burned areas are also recommended for EDRR surveys and treatments.

Within the natural protection areas, it is recommended that all species on the invasive list for this report be considered EDRR species for surveys, treatment and monitoring to protect these sensitive habitats (Table 3). For all other areas, it may be difficult to maintain control of species that occur widespread throughout the fire such as Scotch broom, blackberries, shiny geranium and thistles, therefore, these species should be controlled on a case by case basis depending on the priorities of the individual site. For example, in economically important sites, such as private timber properties, agricultural lands, and state lands managed for timber production, these species may be considered a higher priority for treatment. Other species that are invasive, but not included on the Oregon Department of Agriculture Noxious weed list that may be important species to control in areas managed for timber production include: Oxeye daisy (Leucanthemum vulgare), Foxglove (Digitalis purpurea), Woodland groundsel (Senecio sylvaticus) and Wall-lettuce (Mycelis muralis).

1.4.2. NON-SUPPRESSION EDRR

Natural vegetation protection areas

Non-suppression EDRR treatments and surveys are recommended for the 433 acres indicated by the ETART GIS model (Map 3). This includes natural vegetation protection areas that have intact native plant communities, high to moderate vegetation mortality and/or areas with past restoration activities with invasive plants in close proximity that threaten the native plant communities. For funding considerations, areas within this total can be prioritized based on habitat, level of protection, noxious weeds present, etc. to make surveys and treatments more manageable, rather than trying to include them all at the same time.

Recreational Areas & Open Roadways

Non-suppression EDRR treatments are proposed for high use recreational areas, trails, and open system roads (not covered under suppression) that burned over at moderate to high severity. It is also recommended that boot brush stations be installed at trail heads within these recreation areas.

- Oregon Department of Forestry: 20.8 miles of trails; 7 boot brush stations
- Oregon Parks and Recreation Department: 4 miles of trails; 2 boot brush stations
- Marion County Parks: 5 miles of trails; 5 boot brush stations
- 20 miles of North Fork Road from Hwy 22 to federal lands

Post fire clearing of hazard trees along all major roadways has been extensive along OR Hwy 22 and North Fork Rd. All major travel corridors have patches of high priority weed infestations along their shoulders. Where the native hazard trees and understory are removed, it is very likely that these weed seeds and propagules will quickly establish and colonize the adjacent burned areas, outcompeting native plants. Placement of 2 weed wash stations for vehicles and equipment is recommended. One station near the intersection of North Fork Road and Highway 22 in Lyons and the other in the Scotts Mills area that provides access to the northern section of the fire.

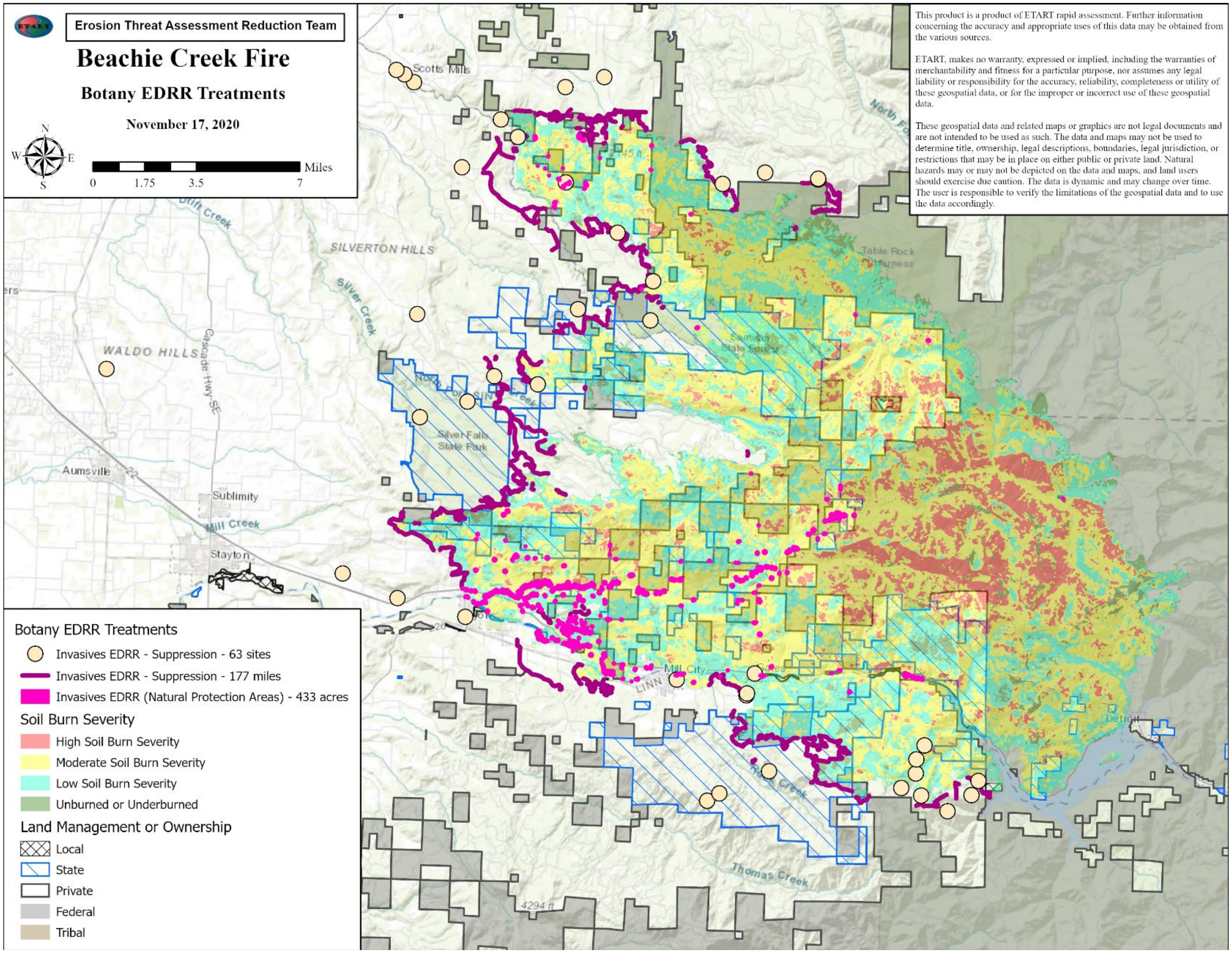
Suppression EDRR

Approximately 177 miles of dozer line, hand line and road as completed line were constructed on non-federal lands. 63 suppression points were used during firefighting activities (Table 5, Map 4). The total acres for suppression points is unknown, but these sites should be surveyed and treated for any potential infestations. For suppression activities on state, county and local lands, landowners/managers should consider excluding traffic and recreation use in these areas until native vegetation is well established (at least 2 growing seasons) (FEIS).

Table 5. Treatment Areas

ETART non-suppression EDRR		
Disturbed Area	**Units**	**Notes**
Natural vegetation protection areas: EDRR surveys/treatments	433 acres	within High/Mod soil burn severity only
Trails and Roads: EDRR Surveys/treatments	49.8 miles	within High/Mod soil burn severity only Trails: 29.8 miles Roads: 20 miles
Trails and Roads: boot brush stations	14 each	1 at each park or recreation area
Trails and Roads: equipment wash station	2 each	Intersection of North Fork Road and Hwy 22 in Lyons; near Scotts Mills

Suppression EDRR		
Disturbance Form	Units	Notes
Dozer lines/hand lines: EDRR surveys/treatments/seeding	177.2 miles/291 acres	on non-federal lands inside and outside of the fire perimeter. Seeding native blue wildrye @ 14lbs/acre
Suppression points: EDRR surveys/treatments/seeding	63	on non-federal lands inside and outside of the fire perimeter(acres not known). Seeding native blue wildrye @ 14lbs/acre



Map 4. Suppression EDRR Treatment Map

1.4.3. BEST MANAGEMENT PRACTICES (BMP) RECOMMENDED

An integrated pest management approach is recommended for treating invasive plants in the Beachie Creek fire. This report recommends two EDRR treatments the first year, spring 2021 and fall 2021. Columbia Gorge and 4-County Cooperative Weed Management Areas (CWMA) have Best Management Practices for treatment of many invasive species described in this report.

Timing of treatments for invasive species is critical for long term control. Some species, such as Himalayan Blackberry require two treatments per year for control. Clean Water Services provides treatment recommendations in a weed control calendar as part of their Integrated Pest Management Plan that can be used to determine the best timing for long term control of invasive plants. The 4-County CWMA also created a weed control calendar in November of 2020. Consultation with a local Oregon Department of Agriculture Noxious Weed Specialist is also recommended for treatments of invasive species.

- Columbia Gorge CWMA Best Management Practices:

  https://columbiagorgecwma.org/weed-listing/best-management-practices/
- 4- County CWMA Best Management Practices:

  https://4countycwma.org/aweeds/best-management-practices/
- Clean Water Services Integrated Pest Management Plan (with weed control calendar in appendix B):

  https://www.cleanwaterservices.org/media/1289/integrated-pest-management-plan.pdf
- 4-County CWMA Integrated Weed Maintenance Calendar:

  https://4countycwma.org/integrated-weed-maintenance-calendar/

Biological Controls

Recovery and maintenance of weed biological control “nursery sites” for insects that have been introduced to help control invasive plants is an important treatment consideration for this fire area. There are several biocontrol agents that were impacted by the Beachie Creek Fire:

- Scotch broom seed predators (2 species)
- Canada thistle agents (2 species)
- Bull thistle seed head fly
- Tansy ragwort control agents (several species)
- Knapweed biological control agents (several species)
- St. John’s-wort root borer and leaf beetles

Education & Outreach

Conduct education and outreach in the communities affected by the fire to teach residents about the invasive species that pose the greatest threats and how to control them. Education on native plants to plant after fires is also important to help re-build resilient native plant communities to resist future invasive plant invasions.

1.4.4. MONITORING RECOMMENDATIONS

Monitoring and treatments for at least 3 to 5 years post fire in critical value habitat areas and in suppression areas is highly recommended. Initial post fire assessments should be made in the spring of 2021. Changes in site conditions should be documented annually in the spring before chemical treatments for up 3 to 5 years. One to two photo points should be set up in areas of highest concern. Photo points should be taken around the same time each year.

Plant community composition will be changing for several years post fire and disturbance from multiple sources will also continue for years. Salvage logging, hazard tree removal, fire event caused tree blow down, clean-up of burned structures, restoration of power to the area, and new construction are all threats that could spread or introduce new invasive plants into the burned area.

Some species, such as knotweeds, may take several years to eradicate from an area. Eradication may not be achieved in only 1 year of treatment if invasives were already present in an area, so it is important to continue treatments and monitoring beyond 1 year.

If there is a heavy infestation that is eradicated within the 3-5 year timeframe, consider seeding with native seed if the natural vegetation is not showing signs of recovery.

1.4.5. FUTURE THREATS/CONSIDERATIONS

- Seed mixes or straw/hay applied by homeowners is a threat to the landscape because it may have contained weed seeds. Free non-native seed was provided by a local business to landowners impacted by the fires. Landowners on Jennie Rd. and Santiam Park Rd. are known to have used this seed mix. All sites are not known as many landowners applied seed from various sources to their properties soon after the fire to help prevent erosion.
- It was not possible to thoroughly assess all burned areas in a short amount of time. There may be localized sites in high and moderate burn severity areas where additional planting and/or seeding are needed that are found with additional surveys and as more areas of the fire are accessed but are not specifically addressed in this report. These areas should be considered for funding as necessary.
- A complete assessment of invasive plants in the entire fire area was not possible for this report and analyses were completed with the invasive plant data that was currently available. There may be additional noxious weeds and invasive plants within the fire area that are not captured in this analysis and report. Adaptations will need to be made throughout the next several years to address additional species that may be found within the fire perimeter.

1.5. References

- Archie Fire BAER report. Botany section
- Beachie Creek BAER Report. Botany Section
- BLM Molalla Watershed Analysis. May 1999
- Boyd, David. 1995. Use of fire to control French broom. In: Lovich, Jeff; Randall, John; Kelly, Mike, eds. Proceedings, California Exotic Pest Plant Council: Symposium '95; 1995 October 6-8; Pacific Grove, CA. Berkeley, CA: California Exotic Pest Plant Council: 9-12.
- Carlton Complex Noxious Weeds and Invasive Plants Report
- Clean Water Services: Weed Calendar/Invasive Plan (online reference)
- CWMA BMP's (online reference)
- Downey, Paul O. 2000. Broom (Cytisus scoparius (L.) Link) and fire: management implications. Plant Protection Quarterly. 15(4): 178-183
- FEIS (Fire Effects Information System) https://www.feis-crs.org/feis/
- InciWeb (Incident Information System) https://inciweb.nwcg.gov/incident/7001/
- North Santiam Watershed Council (NSWC). Watershed Restoration Action Plan. Oct 19, 2014.
- Oregon State Weed Board 2019 (https://www.oregon.gov/ODA/programs/Weeds/Pages/WeedBoard.aspx)
- Oregon Department of Fish and Wildlife Conservation opportunity Areas (Online reference). https://www.oregonconservationstrategy.org/conservation-opportunity-areas/
- Oregon Conservation Strategy Habitats https://www.oregonconservationstrategy.org/strategy-habitats
- Oregon Explorer: https://oregonexplorer.info/content/molalla-pudding-watershed?topic=56&ptopic=98
- Oregon Biodiversity Information Center (ORBIC): https://inr.oregonstate.edu/orbic
- Pausas, J.G. & J.E. Keeley. 2009. A burning story: the role of fire in the history of life. Bioscience. 59: 593-601.
- Poulos, Lauren P. & Bitty A. Roy. 2015. Fire and False Brome: How do prescribed fire and invasive Brachypodium sylvaticum affect each other? Invasive Plant Science and Management. 8(2): 122-130.

2. Engineering Report

2.1. Objectives

Field investigations of existing roads within the boundaries of the Beachie Creek Fire located on non-federal forest land occurred from October 30th-November 15th, 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 Beachie Creek 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
Clackamas County road infrastructure	Low	Property	Damage to existing infrastructure from increased runoff, erosion, and debris flows
Marion County Road infrastructure and County Parks	Moderate to High	Property, Human life and Safety, Natural Resources	Damage to existing infrastructure from increased runoff, erosion, and debris flows
Santiam State Forest Roads	High	Property	Damage to existing infrastructure from increased runoff, erosion, and debris flows
Santiam State Forests Roads	High	Human Life and Safety	Falling trees and rocks, road damage and loss of egress. Access to upper watersheds could pose a safety issue.
Critical Private Road infrastructure	Moderate	Property	Potential for risk to stream culverts plugging due to increased stream flows inside the fire perimeter
General Public including residents, recreationists and commercial traffic	Moderate	Human Life & Safety	Falling trees and rocks, road damage and loss of egress. Access to upper watersheds could pose a safety issue.

2.3. Observations

2.3.1. BACKGROUND

The Beachie Creek 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 the responsibility of the BLM, Clackamas County, Marion County, Oregon Department of Forestry, and a mix of industrial forest landowners. These roads are all located on the western edge of the fire and fell within the low burn severity with sections of moderate severity except for Marion county roadsides which typically burned at moderate burn severity with areas of low and high severity. Nine HDPE culverts on Marion County's North Fork Rd were immediately plated after the burn and subsequentially replaced as soon as possible to allow residents access after the fire. Four points along North Fork road were modeled and identified on the Beachie Creek Fire as high likely hood of debris flow putting the road at risk.

Three of the four Marion County roads that were surveyed are paved and have significant investment in drainage control with well-established and maintained ditches and culverts. The fourth is a graveled road serving residences and Christmas tree farms.

Marion County's hardest hit road, North Fork Road, serves hundreds of year-round residences and is also a heavily used recreation corridor. This road provides access to three county parks, provides roadside access to the Little North Santiam River, Opal Creek Wilderness (USFS) and the Opal Creek Ancient Forest Center.

2.4. Reconnaissance Methodology and Results

2.4.1. BACKGROUND

The Beachie Creek 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 the responsibility of the BLM, Clackamas County, Marion County, Oregon Department of Forestry, and a mix of industrial forest landowners. These roads are all located on the western edge of the fire and fell within the low burn severity with sections of moderate severity except for Marion county roadsides which typically burned at moderate burn severity with areas of low and high severity. Nine HDPE culverts on Marion County's North Fork Rd were immediately plated after the burn and subsequentially replaced as soon as possible to allow residents access after the fire. Four points along North Fork road were modeled and identified on the Beachie Creek Fire as high likely hood of debris flow putting the road at risk.

Three of the four Marion County roads that were surveyed are paved and have significant investment in drainage control with well-established and maintained ditches and culverts. The fourth is a graveled road serving residences and Christmas tree farms.

Marion County's hardest hit road, North Fork Road, serves hundreds of year-round residences and is also a heavily used recreation corridor. This road provides access to three county parks, provides roadside access to the Little North Santiam River, Opal Creek Wilderness (USFS) and the Opal Creek Ancient Forest Center.

2.4.2. METHODOLOGY

Roads were prioritized based on limited resource time and limited resources. A total of approximately 226 miles of roads within or adjacent to the fire perimeter were examined in detail by Engineering.

Within the Marion County road system, the Beachie Creek BAER Basemap identifying roads intersecting likely debris flow segments, topographic map and high-resolution post fire satellite photographs were used with direct observation to evaluate culvert crossings. The results of the field investigations identified risks to human life, safety, and property and natural resources due to the hazards associated with fire adjacent to roads and road systems.

Santiam State Forests Roads were independently assessed outside of the ETART process and the information and data were sourced directly from the ODF staff that is responsible for road and engineering responsibilities.

Road Name or #	Jurisdiction	Total Miles	Mileage within the burn
Elk Prairie	Clackamas County	9	1.2
Sawtell	Clackamas County	14.6	5.52
Family Camp	Clackamas County	2.6	2.6
Copper Creek ML	Private	3.9	3.9
Santiam State Forest	Oregon	190	190
North Fork Rd SE	Marion County	14.1	14.1
Gates-Hill Rd SE	Marion County	3.7	3.7
Wagner Rd SE	Marion County	3.6	3.6
Central St SE	Marion County	1.8	1.8

Park Name	Jurisdiction	Total Acres	Approx. Acres Burned
North Fork	Marion County	18.4	15.6
Bear Creek	Marion County	17.3	17.3
Salmon Falls	Marion County	22.5	22.5

Park Name	Jurisdiction	Total Acres	Approx. Acres Burned
Minto	Marion County	65.5	52.4
Packsaddle	Marion County	5.9	4.7
Niagara	Marion County	40.8	40.8

The number of acres burned within the parks was defined by post burn satellite photograph and field observation of trees killed.

2.5. Findings

Clackamas County

The roads observed on non-federal forest lands pose moderate threat due to their location within the fire and damage observed. These roads will require moderate action to maintain them open and safe to all traffic. There are numerous hazard trees that are immediately adjacent to the road that pose an immediate threat to life and safety. Infrastructure was found along Copper Creek ML in the quantity of 4 culverts. Three of the four crossings are along perineal stream sections and pose a risk to damage or loss to the structure. Sedimentation is already occurring above and within each structure. Most of this sedimentation occurred before the fire but will only worsen due to the changed condition of the fire. With the anticipated increase in flows it is recommended to pull/remove the culverts and provide a temporary harden crossing until the watershed rehabs and the forest reopens this section of the road. At this time a new culvert can be sized and replaced if needed and when needed. This will allow the drainage to establish a post fire flow path, reduce sedimentation and protect the watershed below.

Marion County

Of the approximately 35 miles of County road with the Beachie Creek Fire area this report focuses on the 23 that were most affected by moderate to high burn severity. Along all roads the ditches will need to be cleaned and hazards trees removed along 19 miles of roadside. There are another 153 acres of fire killed trees in county parkland that need to be removed.

The BAER fire intensity map highlighted four locations where there is a high chance of debris flows intersecting the road. Field observations show that these intersections have culverts that are probably undersized for post fire storm flows. These crossings will need to be analyzed and culverts replaced. Consulting engineers have noted an additional culvert crossing that will need to be upsized to pass post burn flows. In addition to culvert work, there are three locations where road repairs are required due to wind thrown trees or burnt stumps causing slope instability and two cliffs where heat loosened rocks are falling into the roadway.

Santiam State Forest

The fire has caused significant damage to the infrastructure. This information is based on the initial assessment of the road system on the Santiam State Forest. There are approximately 190 miles of road within the perimeter of the Beachie Creek Fire on the forest. There are approximately 50-70 polyethylene culverts that have been damaged by the fire and need to be replaced. There are 60-80 locations that will require some level of road repair; cut-slope ravel and ditch cleaning, burnt-out side cast material and road shoulder repair, including a general sweeping/clearing of woody debris that has blown down and adjacent to ditches.

ROAD	DESCRIPTION & ISSUES
Elk Prairie/Sawtell	▪ Well-developed and maintained paved county road ▪ Provides access to numerous rural residential dwellings and private forestland ▪ Needs: storm monitoring and ditch cleaning of all culverts ▪ Critical values at risk – (property)
Family Camp	▪ Surfaced (gravel) county road with heavy truck traffic ▪ Provides access to a minor amount of rural residential dwellings and primary access to state and private forestland. ▪ Connects to State Forests road system: ▪ Needs: hazard tree removal, storm monitoring, and ditch cleaning of all culverts ▪ Critical values at risk – (property & life safety)
Copper Creek ML	▪ Surfaced (gravel) private road with heavy truck traffic ▪ Provides gated access to large tract of private forestland, power line infrastructure, and emergency access to adjoining county and State Highway. ▪ Connects to county road and BLM roads, as well as access to Santiam river drainage. ▪ Needs: hazard tree removal, storm monitoring, and ditch cleaning of all culverts ▪ Critical values at risk – (property & life safety)

ROAD	DESCRIPTION & ISSUES
North Fork Rd SE Santiam State Forest Roads	▪ Well-developed and maintained paved road (major and minor collector functional class) connected to state highway 22. ▪ Surfaced (gravel) state forest roads that are generally open to public access with heavy truck traffic in the form log hauling ▪ Provides access to hundreds of year-round residences, other private timberland, heavily used and USFS/BLM road systems ▪ High public use recreation corridor for County Parks, BLM, USFS and State forests area with multiple developed areas including trail heads and day use areas. ▪ Needs: hydraulic analysis for several culvert crossings and most likely upsizing of culverts, hazard tree removal, storm monitoring and, storm proofing including ditch cleaning, loose rock removal on cliffs, full depth road repair ▪ Critical values at risk – property, life and safety, natural resources armoring, relief dips, and culvert replacement
Gates-Hill Rd SE	▪ Connects Hwy 22 to North Fork Rd (paved, local functional class) ▪ Provides access for a few rural residences, private timberland and power line access ▪ Needs: culvert inlet cleaning, storm monitoring repair, road fore slope slump caused by burned out stump and routes, hazard tree removal ▪ Critical values at risk – property, life and safety
Central Rd SE	▪ Local functional class paved road that parallels Hwy 22 in the town of Gates. ▪ Provides a bypass when crashes close Hwy 22 ▪ Needs: Replacement culvert has been identified as undersized by consulting engineer's analysis. Replace emergency installed culvert with larger one per engineering analysis. ▪ Critical values at risk – life/safety and property
Wagner Rd SE	▪ Local gravel road serving few residences and Christmas tree farms, access to state forestland and USFS ▪ Needs: Hazard tree removal, ditch cleaning and storm monitoring ▪ Critical values at risk – life/safety and property
North Fork	▪ Needs: Remove unstable boulder (11'x6'x7') on steep slope above popular river beach by blasting (supporting tree has burnt away), hazard tree removal ▪ Critical values at risk – life/safety and property
Bear Creek	▪ Needs: hazard tree removal ▪ Critical values at risk – life/safety and property
Salmon Falls	▪ Needs: hazard tree removal ▪ Critical values at risk – life/safety and property

ROAD	DESCRIPTION & ISSUES
Minto	▪ Needs: hazard tree removal ▪ Critical values at risk – life/safety and property
Packsaddle	▪ Needs: hazard tree removal ▪ Critical values at risk – life/safety and property
Niagara	▪ Needs: hazard tree removal ▪ Critical values at risk – life/safety and 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.

2.6.2. HAZARD TREE REMOVAL

Large quantities of hazard trees are an immediate risk to life safety to roads that receive moderate to heavy volumes both public and commercial traffic. The trees also pose a risk to preventing repairs, monitoring, and storm proofing recommendations due to the risk to life and safety when considering proximity to the road and drainage infrastructure. Trees and debris may become lodged in the drainage structures which may lead to problems with normal functions.

Recommendation: Remove or mitigate any trees that poses a threat to the public safety and property that are in proximity to the roads and drainage structures.

2.6.3. STORM PATROLS

The roads at risk within the Beachie Creek Fire burned areas are primarily located within or below areas of High to Moderate burn severity. There is an immediate and future threat to travelers along the roads within the burned area due to the increased potential for culverts to plug with sediment and 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. 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.

Recommendation: Monitor road drainage structures and debris flow treatment structures after significant storm events to ensure the maximum drainage capacity until natural re-vegetation of burned area has occurred. Maintain and repair any damage to road surfaces. Remove sediment and debris from drainage/treatment structures and repair any head cutting in streams and drainages to prevent further degradation of channels. Monitor movement of large woody debris and determine whether 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.

2.6.4. STORM PROOFING, CRITICAL DIPS, AND STORM INSPECTION AND RESPONSE

Clackamas/Private Roads

The Copper Creek ML has multiple culverts that are at risk of damage from erosion due to plugging/blocking. This often occurs when ash and sediment loads are deposited into roadside ditches. When a storm event occurs the ash and sediment collect at the inlet of a culvert so that it has the potential to become plugged. The culverts are also not designed for increased flows and have a high potential for overtopping/failure. There are multiple ditch relief culverts along the 3.19 miles of Copper Creek ML within burned area. These sections are at risk of plugging/failing, resulting in property loss and natural resource damage from increased sedimentation to the watersheds.

Photos 1 and 2: Culverts along Copper Creek mainline

State Forests

Santiam State Forest roads primarily lie within areas that were moderate to high intensity that resulting in damage and immediate risks to further damage due from erosion to plugging. Post fire assessments have noted numerous drainage structures that are not functioning due physical damage (burned) which have decreased the capacity to convey water. The increase in sediment load is also decreasing water capacity as rain events are increasing in frequency. The loss of the herbaceous and small brush component within the ditches and slopes is resulting in drainage structures to fill with fine sediment. To ensure proper function continues through rain and storm events, there will be a need to storm proof and monitor the roads until the threat has been reduced or repairs have occurred.


Photos 3 and 4: Culverts along Copper Creek mainline

Recommendation (all): Clean culverts, run out ditches, and catchment basins of sediment, debris and rock. 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 possibility of sediment and debris plugging of existing culverts.

Storm proofing of the road is vital to the protection of the property. These roads are not designed for the post fire environment leaving them at risk for massive failure. Culverts that lie within/transect high burn severity are in danger of future failure. Along these sections it is recommended to clean/pull ditches, clean culvert inlets/outlets and out slope the road prism where appropriate.

Storm inspection response is key once the roads have been storm proofed. Monitor storms over the fire for the first year and send personnel out to inspect after a storm passes. React as appropriate for each storm. Re-storm proof after any damaging storm to keep ditches, culverts and critical dips in working order.

Install rolling dips where they will be most efficient and necessary. Rolling dips should be constructed along straight tangents of the road especially around cross drainpipes to aid in drainage. Critical dips should be installed on the down slope side of cross drain culverts to be left in place and in locations where culvert failure is possible or likely. These rolling dips will assist to remove water from the roadbed that has become trapped on the road surface causing erosion and travel hazards. Any culverts replaced should be sized on predicted increase in flows and installed with minimum cover and heavy armoring.

2.6.5. CULVERT REPLACEMENT (MARION COUNTY AND SANTIAM STATE FORESTS)

Santiam State Forests

Currently there are approximately 70 existing stream crossings and cross drain culverts (polyethylene) that need to be replaced or repaired that are within the moderate to high burn severity areas. These culverts are not currently fully functioning, blocked, burned, or have a high probability of not functioning in the near future due potential for sediment delivery. The culverts will need to be prioritized for replacement and repairs based on internal threat assessments and the needs of the State Forest division.

Marion County

Nine culverts on North Fork road burned and were replaced as soon as possible after access was allowed. These culverts will be monitored with all the other culverts in Marion County's road system in the burned area. Four areas were identified as having a high likelihood of debris flow intersecting the road. These crossings have metal pipes and survived the fire but need hydraulic analyses to see if culvert replacement and upsizing is warranted. One culvert in particular has evidence of being undersized for pre-burn conditions by scour above the top of inlet and a sizable plunge pool at the outlet. There is the possibility that all crossings need upsized culverts.

Central Rd SE had an emergency replaced culvert in the town of Gates. Subsequent consulting engineer's analysis has shown that the new culvert is undersized for post burn flows and will need to be replaced.

Recommendation: 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. On the Santiam many of the culverts

2.7. Management Recommendations

2.7.1. STORM PATROLS

Storm inspection and response is only funded by BAER funds for the initial year of implementation.

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

2.7.2. LOW RISK ROADS & ROADS OUTSIDE BURN PERIMETER

Roads that were gated closed along the 8400 system seemed to be at low risk due to location and proximity to low burn severity.

Recommendation: Continue to enforce any closures in place and keep an eye on these roads after significant storms.

2.7.3. COOPERATOR NEEDED ROADS

Roads used primarily by BPA for access to powerline. Many roads appear to be Forest Service Jurisdiction, but primarily maintained by BPA.

Recommendation: Forest Service personnel should coordinate with cooperators to recommend storm patrol on these roads, especially 8400777. Good and constant maintenance and continual storm patrol will be needed to protect the road and associated water quality in the Tanner Creek drainage.

2.8. References

Clackamas County Road Department Cost Estimates. Clackamas County, OR 2020

Oregon Department of Forestry, State Forests Division. Forest Roads Manual and cost estimates from pending public contracts. Nov. 202.

3. Heritage and Cultural Resources

Claeyssens, Paul G.
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 Beachie 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 Beachie 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 Beachie Creek Fire located in Clackamas and Marion Counties, Oregon started on August 16, 2020 and by October 31, 2020 had burned over 192,631 acres. The soil burn severity on state and private lands was Moderate on 10,042 acres, and High on 5,296 acres.

Table 1: Soil Burn Severity by Ownership

Soil Burn Severity	Willamette	Mt. Hood	BLM	USACE	State	Local Govt.	Private	Total	% of Burn Area
Unburned	1,937	266	1,903	40	2,249	0	2,067	8,462	4.4%
Low	9,571	281	15,341	286	10,957	77	26,768	63,280	32.9%
Moderate	26,353	30	19,177	160	9,891	151	45,158	100,921	52.4%
High	12,561	0	2,150	0	946	0	4,310	19,967	10.4%
Total	**50,423**	**577**	**38,571**	**486**	**24,043**	**228**	**78,303**	**192,631**	

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 four 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 Treatments

The Forest Service lands within the Beachie Creek Fire were also subjected to a post-fire assessment process. The USDA FS BAER team archaeologist identified a total of four cultural resource sites with critical values. They proposed treatments are administrative closure of access roads and mulching to cover exposed deposits to prevent looting and vandalism. They further recommended monitoring of the four remaining sites to track changed condition and potential damage from looting or 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

*<u>Probability of Damage or Loss</u>: 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%)

<u>Magnitude of Consequences</u>:

- 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 pink 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

Anthony Collora, Natural Resources Conservation Service
anthony.collora@usda.gov

4.1. Summary

4.1.1. OBJECTIVES

This soil resource condition assessment has been conducted by an Erosion Threat Assessment Response Team (ETART), in which the primary objective was to create a landscape level post-fire risk assessment for private and state lands within the Beachie Creek Fire. This assessment will support the prioritization of emergency funding for state and locally administered recovery programs and strategize responses. Assessments and modeling efforts have been completed for sub watersheds and drainages in which critical values were identified. Risks were assigned based on potential threats to human life, property, and critical natural and cultural resources.

This assessment is meant to serve as a broad landscape-level evaluation of post fire risk. It is not intended to serve as a site-specific evaluation of post-fire erosion threat, nor is it intended to identify site-specific long-term rehabilitation or restoration treatments. This is due to the scale at which the hazards were assessed and selected subcatchments were modeled. This assessment’s target audience is state and private landowners; it is meant to help assess risk to determine the level of threat to any values within or downstream of the fire and make appropriate management decisions at the landscape level.

4.1.2. CRITICAL VALUES

The critical values that have been considered during ETART assessments include human life and safety, property, infrastructure, natural resources, and cultural and heritage resources. Generally, these critical values are located along the main road corridors and along major drainageways. Natural resource values across the entire fire area include habitat for Chinook Salmon, Coho Salmon, Steelhead Salmon, Bull Trout, and Northern Spotted Owl.

The following critical values have been outlined by HUC12 watershed. Critical values will be related to how WEPP modeling was conducted at the subwatershed level.

Middle Butte Creek

- S Butte Creek Rd is a main road within this sub watershed. S Butte Creek Rd provides access to private property that is located east of the town of Scotts Mill. The road is located along Butte Creek and Coal Creek.

Upper Butte Creek

- Trails and road access to the Santiam State Forest
- Steep hillslopes with varying degrees of soil burn severity drain into Butte Creek

Pine Creek - Molalla River

- Gawley Creek has a large catchment area and flows into Molalla River.

Headwaters Molalla

- Headwaters of the Molalla River contain a significant area of moderate and high soil burn severity. Critical value is the Molalla River.

Stout Creek - North Santiam River

- The town of Molalla is at the outlet of Stout Creek as it joins the Santiam River. Property and Infrastructure located north of the Santiam River, and close to the outlet of Stout Creek is of critical value within this watershed.

Lower Little North Santiam River

- Private Property and Infrastructure along North Fork Rd
- River access and parks/boat ramp areas along North Little Santiam River

Middle Little North Santiam River

- Private Property and Infrastructure along North Fork Rd
- River access and parks/boat ramp areas along North Little Santiam River

Upper Little North Santiam River

- Private Property and Infrastructure along North Fork Rd
- River access and parks/boat ramp areas along North Little Santiam River

Walker Creek-North Santiam River

- Drainages effected by the fire are situated above the town of Mill City, this presents a risk to private property and infrastructure located on the north part of town, property north of OR-22.
- Drainage along Hudel Rd, as one travels north out of Mill City

Mad Creek-North Santiam River

- Steep south facing hillslopes abutting OR-22 pose a threat to the road and transmission line infrastructure along and above OR-22.
- All drainages modeled in this watershed flow into town of Gates, the critical values at risk include private residential property, roads, and infrastructure.

- Minto County Park, a public park on the banks of the Santiam River

Sevenmile Creek-North Santiam River

- Steep south facing hillslopes abutting OR-22 pose a threat to the road and transmission line infrastructure along and above OR-22
- Private property and infrastructure in the town of Niagara. Niagara Creek's drainage path is along Niagara Heights Rd and 3rd Street SE.
- Niagara Park and Packsaddle Park, both are public parks along the banks of the Santiam River.

Kinney Creek-Detroit Reservoir

- Sardine Creek and Mayflower Creek basin. USACE is concerned with debris flow/ sediment into Big Cliff Reservoir
- Detroit Reservoir is a critical value. It provides municipal water to Salem, sedimentation and debris contamination into the reservoir is a concern of the Santiam Water Control District.

4.2. Resource Condition and Setting

4.2.1. BACKGROUND

The Beachie Creek Fire started on August 16, 2020 roughly two mile south of Jawbone Flats in the Opal Creek Wilderness in the Willamette National Forest. The fire showed minimal signs of growth until a historic easterly wind event occurred the evening of Monday, September 7, resulting in rapid growth of the fire. Within days, the fire grew to approximately 193,000 acres. The fire spread quickly through the Willamette National Forest and pushed its way east onto private and state lands as it consumed parts of the towns of Detroit, Niagara, Gates, and Mill City. The areas with significant damage and continued risk to property and infrastructure are concentrated on the OR-22 corridor and along the North Fork Santiam River.

4.2.2. CLIMATE

The climate within the Beachie Creek fire varies by elevation, but is regarded as a Mediterranean climate, with roughly 80% of precipitation occurring in the winter months from November through January. The annual average precipitation ranges with elevation, but varies from 60 inches in the lower elevation, western sections to 114 inches at the higher elevation areas in the eastern portions of the fire. Elevation ranges from roughly 800 feet to over 5000 feet. The vegetation communities and ecological sites are diverse through this region, ranging from chaparral woodlands and shrublands, to dense stands of conifers with thick understories of ferns and shrubs.

4.2.3. GEOLOGY AND SOILS

Soils within this fire commonly have surface textures of silt loam, loam, or clay loam. The upland soils commonly form from glacial deposits, colluvial materials, residuum, and landslides. Soils range in rock fragment content across the region. Typically, the skeletal soils are associated with glacial deposits and colluvial deposits. Rock outcrops and screes occur on steeper areas and mountain slopes. Soils with andic soil properties are common throughout the region. The landscape of this region features active landslides, and soils with the natural tendency to slough material, this is due to the soil textures, steep slopes, geology, and climate. Bedrock geology within the fire perimeters of the Beachie Creek and Riverside fires consists of mostly Late Oligocene and Miocene volcanic and volcanic-sedimentary rocks with occurrences of alluvial fan deposits in the Elkhorn Valley area. Volcanic rock types are resistant to weathering and erosion and contributes to the slope steepness and topography within the fire perimeter. Soil types and erosion hazard are detailed in Appendix C.

4.2.4. SOIL BURN SEVERITY

The distribution of high burn areas, based on the soil burn severity (SBS) map, occurred on higher elevations such as ridgelines and peaks. Lower elevations were observed as being unburned or with lower burned severity soils within the watersheds and riparian areas due to the heterogeneity of vegetation and moisture content of the soils. Moderate and high soil burn severity was consistently observed on south facing slopes, such as the south facing slope of Elkhorn Mountain on Beachie Creek. South facing slopes are generally drier and therefore ground fuels were less resistant to fire. See Table 1. on page 79.

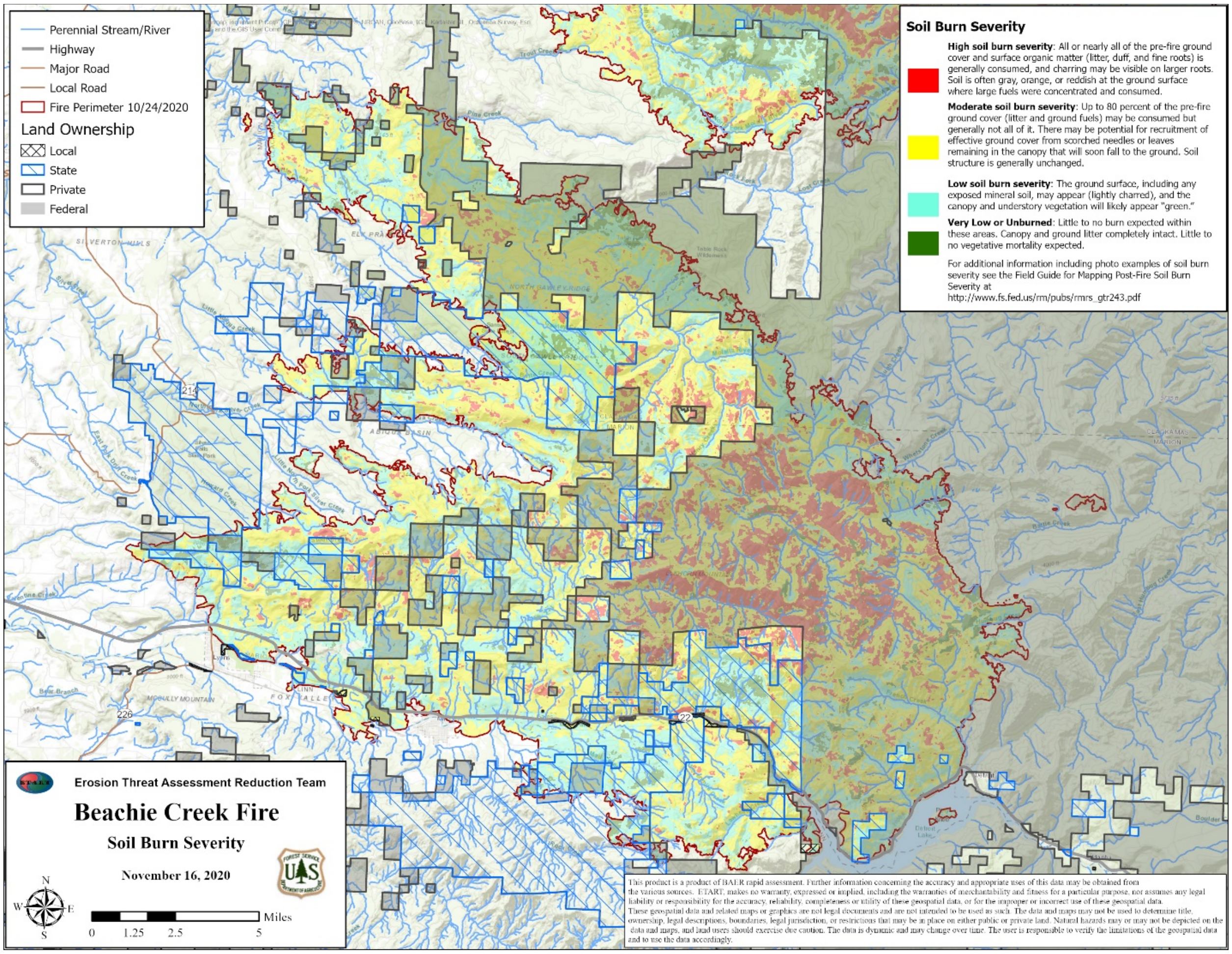


Figure 1. ETART Soil Burn Severity Map – Beachie Creek Fire

4.3. Assessment Methodology

Field assessments consisted of data validation and identification of critical values at risk. Field assessments were completed using the criteria outlined in Field Guide of Mapping Post-Fire Soil Burn Severity (RMRS-GTR-243). Partners from the NRCS and FS 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. Pre-fire land management conditions and vegetation was an important part of judging the soil burn severity as well as potential risks. Since much of this fire affected private industrial forestry land under clear-felling rotations, erosion potential for selective sub watersheds and drainages were taken into close consideration. In some cases, small acreage private homesites were located downstream and downhill of private industrial forest land.

Prior to the ETART effort, partners working for the Forest Service created a Soil Burn Severity (SBS) map based on pre and post fire imagery as well as aerial assessments. The Soil Burn Severity map contains 4 classes of burn severity: unburned, low SBS, moderate SBS, and high SBS. The Forest Service-generated SBS mapping did not field validate soil conditions on private or state lands. The ETART soils team validated the soil burn severity map with on-the-ground data collection and visual validation on state and private lands. This was done to ensure that the WEPP erosion modeling effort would produce a meaningful output for the watersheds identified. A table of field indicators used in field validation of SBS can be found in Appendix C.

In addition to the field assessments on soil and site conditions, members of the ETART soils sub-team spent time to identify critical values potentially at risk. Once the soil burn severity maps were field validated and critical values identified, the modeling effort began.

The ETART soils sub-team used the erosion modeling tool WEPP, which is hosted by the University of Idaho. WEPP Disturbed is the specific model that was used to assess erosion risk. It uses Soil Survey Geographic Database (SSURGO) data produced by the NRCS as well as data from National Land Cover Database (NLCD) to parameterize land use for unburned conditions. The Soil Burn Severity map is then fed into the WEPP Disturbed model, resulting in outputs that provide meaningful comparisons between unburned and burned conditions. The two output parameters that were used to judge the erosion potential were: Total Hillslope Soil Loss from Outlet (ton/yr) and Total Hillslope Soil Loss per unit area of watershed (lb/acr/yr). The soil loss results varied greatly depending on the size and characteristics of each modeled subcatchment, and its associated soil burn severity. The ETART soils sub-team determined that the output values of hillslope soil loss per year that WEPP model produced represents a general magnitude of watershed response under average conditions, rather than an precise reflection of total possible erosion; however the comparison between the pre-fire and post-fire values were determined to be a meaningful and significant judgement of risk based on typical storm event and soil erosion behavior for the area.

4.4. Findings

A total of 45 drainages across 12 subwatersheds (HUC12) were modeled for hillslope soil loss using the WEPP Disturbed model. Each drainage was modeled twice, first for unburned conditions, and the second utilizing the Soil Burn Severity map as an input. The magnitude of hillslope soil loss was determined by calculating the difference in hillslope soil loss from the unburned to the burned state. The report generated the soil loss calculated at outlets (tons/yr) as well as soil loss per unit area of watershed (lb/acr/yr). The ‘Magnitude in Post-Fire Hillslope Soil Loss’ is the average between those two hillslope loss equations (soil loss from outlet and soil loss per unit area of watershed). Please see Table 2. on the following page.

Table 1: Summary Breakdown of Soil Burn Severity by Land Ownership

Soil Burn Severity Rating	Total Acres	Total (%)	Federal Land (acres)	Federal (%)	Private Land (acres)	Private (%)	State Land (acres)	State (%)	Local Land (acres)	Local (%)
High	19968	10	14710	16	4310	6	948	4	0	0
Moderate	100900	52	45703	51	45143	58	9903	41	151	66
Low	63092	33	25423	28	26654	34	10939	46	76	33
Unburned	8364	4	4106	5	2026	3	2232	9	0	0
Grand Total	**192324**		**89942**		**78134**		**24021**		**228**	

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

			Unburned		Burned		
Subwatershed	**Drainage Name**	**Actual Outlet Location used in Modeling**	**Total Hillslope Soil Loss (ton/yr)**	**Total Hillslope Soil Loss per unit area of watershed (lb/acr/yr)**	**Total Hillslope Soil Loss (ton/yr)**	**Total Hillslope Soil Loss per unit area of watershed (lb/acr/yr)**	**Magnitude in Post-Fire Hillslope Soil Loss (average)**
Middle Butte Creek	Little Coal Creek	-122.556948, 44.993925	200	290	450	660	**2.26**
	Coal Creek	-122.556547, 44.993212	170	140	490	410	**2.91**
	Coal Creek Trib	-122.559063, 44.991007	210	2100	800	7700	**3.74**
Upper Butte Creek	Upper Butte Creek	-122.445390, 44.906244	800	530	1600	1100	**2.04**

			Unburned		Burned		
	Kirk Creek	-122.507017, 44.917941	250	230	1000	940	**4.04**
Pine Creek - Molalla River	Gawley Creek	-122.458292, 44.954044	2300	800	4100	1400	**1.77**
Headwaters Molalla	Henry Creek	-122.321868, 44.911915	3400	1900	9100	5100	**2.68**
	Upper Molalla River (above Henry Ck)	-122.321489, 44.912885	2500	1200	3500	1700	**1.41**
	Ogle Creek	-122.330127, 44.914142	410	990	1200	3000	**2.98**
	Copper Creek	-122.338644, 44.923833	820	380	2900	1300	**3.48**
	Mining Iron Creek	-122.341449, 44.925614	5600	770	18000	2500	**3.23**
	Minette Creek	-122.364107, 44.935860	100	240	270	640	**2.68**
Stout Creek - North Santiam River	Stout Creek	-122.614637, 44.800022	450	210	1200	570	**2.69**
Lower Little North Santiam River	Polly Creek	-122.547023, 44.795957	35	76	260	570	**7.46**
	Jeeter Creek	-122.530287, 44.797159	27	130	110	500	**3.96**
	Kiel Creek	-122.519329, 44.798112	71	120	480	770	**6.59**

			Unburned		Burned		
	Beaver Creek	-122.518948, 44.796868	79	130	470	770	**5.94**
	Little NF Trib	-122.491257, 44.797081	20	79	150	590	**7.48**
Middle Little North Santiam River	Canyon Creek	-122.480917, 44.801023	210	200	720	700	**3.46**
	Cougar Creek	-122.446657, 44.803086	29	150	120	600	**4.07**
	Moorehouse Creek	-122.414864, 44.801073	13	49	77	280	**5.82**
	Little NF Trib 2	-122.402917, 44.808267	18	79	250	1100	**13.91**
	Little Sinker Crk	-122.414843, 44.808094	1.9	2.5	56	74	**29.54**
Upper Little North Santiam River	Buck Creek	-122.382969, 44.809961	2.8	89	27	860	**9.65**
	Buck Creek Trib	-122.381967, 44.810235	77	140	320	570	**4.11**
	Fish Crk	-122.394614, 44.823428	0.88	12	15	210	**17.27**
	Fawn Creek	-122.372976, 44.832340	7.6	35	32	150	**4.25**
	Evans Creek	-122.360933, 44.839106	1200	1200	3200	3000	**2.58**

			Unburned		Burned		
	Darling Creek	-122.365120, 44.836906	4.3	17	23	91	**5.35**
Walker Creek-North Santiam River	Santiam Trib 1	-122.473319, 44.757894	0.88	8.8	6.9	69	**7.84**
Mad Creek-North Santiam River	Anderson Creek	-122.451643, 44.755902	0.66	50	1.4	110	**2.16**
	Pierce Creek	-122.431235, 44.758854	0	0	0.11	5.7	
	Gates Hill Trib 1	-122.424012, 44.757161	13	27	130	270	**10.00**
	Gates Hill Trib 2	-122.417095, 44.760259	6.2	110	36	650	**5.86**
	Gates Hill Trib 3	-122.409943, 44.760339	5.8	50	49	420	**8.42**
	Roland Creek	-122.399360, 44.761004	48	110	320	710	**6.56**
	Minto Creek	-122.390720, 44.757123	48	130	170	480	**3.62**
Sevenmile Creek-North Santiam River	Packsaddle Road Trib	-122.378452, 44.757120	15	98	53	330	**3.45**
	Packsaddle Creek	-122.364278, 44.758069	32	150	110	510	**3.42**
	Bad Banks Creek	-122.343755, 44.760680	330	480	1500	2200	**4.56**

			Unburned		Burned			
	Niagra Creek	-122.335901, 44.758042	29	270	59	550	**2.04**
	Lodore Creek	-122.305816, 44.757107	24	150	21	130	**0.87**
	Sevenmile Creek	-122.331859, 44.751330	1300	1100	3900	3500	**3.09**
Kinney Creek-Detroit Reservoir	Big Cliff Trib 1	-122.274488, 44.734460	160	1600	510	5300	**3.25**
	Sardine Creek	-122.272430, 44.748428	3900	2300	7800	4700	**2.02**

4.5. Recommendations

Due to the scope and scale of the ETART fire assessment, 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. For a full list of post-fire treatments refer to USFS Burned Area Emergency Response Treatments Catalog (0625 1801-SDTDC). When selecting the appropriate treatment for individual sites, the following considerations should be taken into effect:

- Nature of downstream values at risk.
- Effectiveness of treatment.
- Treatment combinations (land, channel, road/trail, protection/safety) to reduce risks.
- Timeframe for implementation.
- Personnel and resources available for implementation and monitoring.
- Hazards associated with treatment implementation.
- Ease of treatment implementation.
- Cost effectiveness of treatments.
- Coordination with other Federal, State, and local agencies

The following response actions adheres to guidance for BAER risk assessments and treatments set forth by the Forest Service. Treatments are focused primarily on mitigating potential risks to human life and safety, property, infrastructure, and natural or cultural resources. The following treatments are merely recommendations made during a rapid assessment and modeling effort. Damage or loss to critical values can occur irrespective of the predicted risk.

For areas along the OR-22 corridor from Detroit to Lyons within the Walker Creek- North Santiam River, Mad Creek- North Santiam River, Sevenmile Creek- North Santiam River, and Kinney Creek-Detroit Reservoir watersheds: Several south facing hillslopes abutting the highway have been determined to have intermediate to high degrees of risk. The steep south facing slopes have low to high soil burn severity, and areas of high soil burn severity occasionally occur in headwaters of small drainages adjoining the highway. This presents risk of debris flow and soil loss depositing onto sections of the highway that already have little to no shoulder. The risk to human safety is increased due to the nature of the narrow and windy road; motorists might not be able to safely assess hazards on the roadway with enough time and space to safely avoid them. The recommended hillslope treatment in these cases would be a combination of hazard tree removal and cross felling trees to create log erosion barriers. The ground conditions at the headwaters of these drainages were not able to be field verified due to lack of access, however depending on field observed soil burn severity and erosion potential, additional land treatments may be necessary to minimize the risk of erosion and debris flowing onto the highway. While the road and engineering risks are being assessed, deployment of warning signage and closely monitoring hazards is recommended in the interim.

For those drainages located within the Lower Little North Santiam River, Middle Little North Santiam River, and Upper Little North Santiam River watersheds: There are many private properties and residences along North Fork Rd. Some properties are located close to or adjoining the outlets to several drainageways that have WEPP erosion modeling. Generally, there is a low degree of risk associated with potential hillslope erosion and sediment deposition. Additionally, multiple properties are located along the floodplains and banks of the Little North Santiam River, in certain cases, moderate and high soil burn severity has been identified in the drainageways that flow into the river. Specific treatments cannot be recommended on a per property basis, however there are a variety of treatments that are proven effective against low degrees of hillslope erosion. These include, but are not limited to mulching, slash spreading, erosion barriers, wattles, silt fences, debris deflectors, and protective fences. Residents of this area should also have access to flood warning systems, should a major rainfall event occur.

For those areas within the Stout Creek- North Santiam River watershed: Stout Creek has been modeled to have an approximate hillslope soil erosion increase of 269% compared to unburned conditions. The town of Mehama is directly below the outlet of Stout Creek, as it meets the Santiam River. Property and infrastructure located north of the Santiam River has a higher degree of risk (than values located south of the river), should a debris flow occur in this drainage. Access into this drainage was not possible for field validation, so actual ground conditions and risk is unknown. Treatment considerations should follow the same approach as those values identified along North Fork Rd. Since ground conditions in the fire effected area are unknown, specific treatments cannot be recommended with confidence.

For areas within the Upper Butte Creek watershed: generally, there is a low degree of risk within this watershed. There are no private residences that could be identified using satellite imagery, therefore damage to property is not a concern. This watershed does provide access into Santiam State Forest. Access roads should be assessed to determine any engineering risks to culverts or bridges. Public access and trails within the Santiam State Forest should be closed until long-term risk to public safety can be mitigated, this goes for all areas of the forest, not specifically those within the Upper Butte Creek watershed.

For areas within the Middle Butte Creek watershed: the values at risk within this watershed is private property and infrastructure located along the South Butte Creek Road corridor. The hillslope soil erosion models approximate an increase of 270% compared to unburned conditions. There are several private residences that could be affected should a major rainfall event occur. Similar land treatment recommendations should be considered as previously outlined. In addition, residents in this area should have access to flood warning systems.

4.5.1. RECOMMENDED MONITORING

Continued monitoring will be necessary for the roads and highways that access private property. It was determined there is a likely probability of sediment and debris sloughing onto roadways and highways due to the severity of the fire in some areas, as well as the steepness of some slopes along roadways. Soil erosion and debris sloughing will likely occur during and after significant rainfall events. For this reason, storm patrolling may be necessary to ensure public safety.

For the majority of the areas affected by this fire, long term monitoring will not be necessary, especially in areas that have no infrastructure, private residences, nor significant investments. Natural recovery is typically the best course of action in these remote areas because of the limited active treatment options that are both economically viable and effective for slowing erosion and mitigating mass movement.

5. Hydrology Resources

Ryan Andrews, Oregon Water Resources Department
W. Terry Frueh, Oregon Department of Forestry
Spencer Higginson, National Weather Service
Kyle Wright, United States Forest Service

5.1. Objectives

The objectives of this report are focused on Beachie Creek Fire:

- Assess impacts of watershed changes caused by the fires, on values on non-federal lands, particularly 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 areas 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.

Note that Lionshead was not extensively assessed in this report. However, there were a few values that were on the western edge of this fire, adjacent to Beachie Creek Fire, that were assessed.

5.2. Critical Values

Critical values with elevated risk of damage from post-fire erosion, flooding, and debris flows within and downstream of the Beachie Creek and Lionshead fires exist on private, state and local government, and National Forest Service (NFS) land. We also assessed hazard trees impact to terrestrial recreation sites since we were there. The Erosion Threat Assessment/Reduction Team (ETART) program assesses and treats critical values on nonfederal land, but not for Oregon Department of Transportation (ODOT) or county roads, or NFS inholdings (e.g., Breitenbush resort) since those values were assessed elsewhere. Due to the large geographic extent of these fires, this report will summarize values at risk (VAR) while an extensive list of VARs related to hydrologic response can be found in Appendix G. Note that because of challenges both in obtaining landowner permissions and the logistics of covering such a large area, this effort did not extensively analyze with site visits values on private property that covers much of the non-federal portions of the fire.

5.2.1. WATER QUALITY

Water quality is a major concern post-fire as elevated erosion rates and stream flows can impact drinking water supplies and associated filtration systems. The City of Salem's slow sand filtration system on the North Santiam River, just downstream of Mehama, is influenced by the highly impacted Little North Santiam River and is very susceptible to increased turbidity, organic matter, ash and other pollutants. Increased sediment and debris transport can also increase sediment loading and reduce water storage capacity in flood storage reservoirs. Aquatic habitat can also become degraded with increased fine sediment and reduced stream shading post-fire. Water quality managers in the North Santiam Basin are also considering the potential for increased harmful algal blooms due to sediment transport into Detroit Lake. Continued communication and coordination with partners and downstream users related to water quality is considered essential for relaying the ETART assessment findings, particularly with municipal water supply providers and the Army Corps of Engineers.

The Beachie Creek and Lionshead Fires impacted source water drainages for numerous municipal and private domestic drinking water supplies. Downstream municipal users dependent on rivers originating in the fire area include: Salem, Stayton, Lyons, Mehama and Gates on the N. Santiam River, Idanha and Detroit which are reliant on the Rainbow and Mackey drainages, respectively, and Jefferson and Albany with intakes on the Santiam River. Private users include Breitenbush Hot Springs Resort, the N. Santiam Sportsmen Club, Opal Creek Ancient Forest Center, and residential intakes for recreational residences in the Stahlman and Breitenbush areas. Oregon State Parks and Recreation maintains a water intake on Tumble Creek and several Forest Service Campgrounds rely on water from Mansfield Creek and other unnamed tributaries. Some of these intakes have been damaged in the fire and new systems will need to be developed. City of Molalla water intake is below the burned areas in both Riverside and Beachie Creek Fires. Other systems are at threat of degraded water quality or at risk of intakes and systems becoming clogged or damaged by high flows. Drinking water supplies are discussed in more depth in other reports.

Landscape scale treatments to reduce erosion, debris hazards, and mitigate post-fire impacts to water quality were considered but not proposed. Areas for potential treatment were assessed by first identifying treatable hillsides based on slopes, narrowing in on contiguous patches of treatable slopes above values at risk, assessing feasibility of implementation, and analyzing potential effectiveness to reduce water quality impacts to values at risk. Areas that were theoretically treatable were found to be not practical to treat due to lack of access for equipment, timing of treatments in relation to upcoming wet season, and location of hillslopes in proximity to access for stockpiles and helicopter turnaround times. It was determined that application of these treatments, where feasible, would not be at a scale large enough in relation to the proportion of untreatable areas to reduce associated water quality risks. Additional information related to landscape scale treatments can be found in the ETART Soils Report.

5.2.2. LIFE AND SAFETY CONCERNS FROM FLOODING AND DEBRIS

ETART assessments focus on locations where people may be at risk from more rapid increases in flood flows and debris-laden flood waters on nonfederal lands. On the Beachie Creek and Lionshead

Fires, this includes many recreational use locations in the Little North Santiam drainage and Detroit Lake where boaters could crash into pieces of large wood. Due to likely increased debris transport into Detroit Lake, coordination with USACE and OR State Marine Board is recommended to reduce risk to boater safety and dam operations. Additionally, hazard trees at recreation sites (e.g., parks, campgrounds, boat ramps) threaten lives and safety if not properly mitigated. Permitting and support for an Early Warning System to alert downstream users of potential flooding during large storm events is recommended to mitigate flood risks to private landowners.

5.2.3. PROPERTY RELATED CONCERNS FROM FLOODING AND DEBRIS

The biggest threats to property were due to sediment and debris clogging water intakes. Additional information related to debris and flooding hazards can be found in the ETART Geology and Engineering Reports.

5.3. Resource Condition and Setting

The Beachie Creek and Lionshead fires encompassed areas on state, federal, and private lands within the Upper Molalla River watershed (HUC10) and North Santiam sub-basin (HUC8) and its watersheds, including the Breitenbush River, Headwaters of North Santiam, Upper, Middle, and North Santiam Rivers, and the Little North Fork Santiam River. The fire area on state lands occurred mainly in the Upper and Middle North Santiam watersheds adjacent to and downstream of Detroit Lake, as well as portions of the Little North Fork Santiam and Molalla River watersheds. However, burned areas upstream will likely have an impact on state and county properties further downstream. City water intakes for communities within the burned areas have been identified in areas with the potential for elevated risk due to hydrological impacts.

5.3.1. GEOLOGY

The fire area encompasses a combination of older Western Cascades and younger High Cascades landforms formed and shaped by processes of volcanism and modified by glaciation. The Little North Santiam, Upper North Santiam, and lower elevations/western portions of the Breitenbush River are part of the Western Cascades region, characterized by older and more weathered parent material, with heavily eroded rock and easily mobilized fine-grained sediment. Slow-moving earth flows, landslides, and subsequent debris flows in this portion of the fire area have been responsible for numerous road failures, as well as downstream water quality impacts (Sobieszcyk et al, 2004). Higher in elevation the High Cascades landform dominates, such as in the alpine area around Mt. Jefferson, where surface rock is younger and less weathered, sediment transport in streams is primarily reflective of seasonal snowmelt, glacial melt, and very rare glacial outburst events.

The burned areas of the Upper Molalla Watershed begin in the headwaters near Table Rock Wilderness and extend downstream to the confluence with Pine Creek. The Molalla River exclusively drains the less permeable igneous complex of the Western Cascade Range. The layered nature of the basalt/andesite and pyroclastic igneous rock parent material can create unstable slope conditions in the Upper Molalla drainage (BLM, 1999).

5.3.2. CLIMATE

Average annual precipitation across the fire area ranges from 65 inches at the western and lower elevation drainages closer to the Willamette Valley, up to 90 inches at Detroit Lake. Precipitation falls predominately as snow at higher elevations in the headwaters of the Breitenbush and North Santiam Rivers. Almost all precipitation in the area falls between October and May, due to Pacific maritime frontal storms dominated by 5 – 10 inches of rain over 18 – 36 hour periods from October through January. Snowfall accumulation begins in higher elevations from mid to late November continuing through April. Rain-on-snow events are common, typically occurring from November through January, and range in their magnitude of hydrologic responses. Occasionally, convective storms occur over small areas and create localized effects from high intensity, short-duration rainfall.

Wet, mild winters characterize the Molalla sub-basin, with average annual precipitation reaching 100 inches in the mountains and about 40 inches on the valley floor. Snow pack plays only a minor role in overwinter storage of precipitation. Given the range in elevation within the watershed, and the occurrence of heavy snowfall at higher elevations, rain-on-snow events have contributed to extreme high flows during storm events (BLM, 1999).

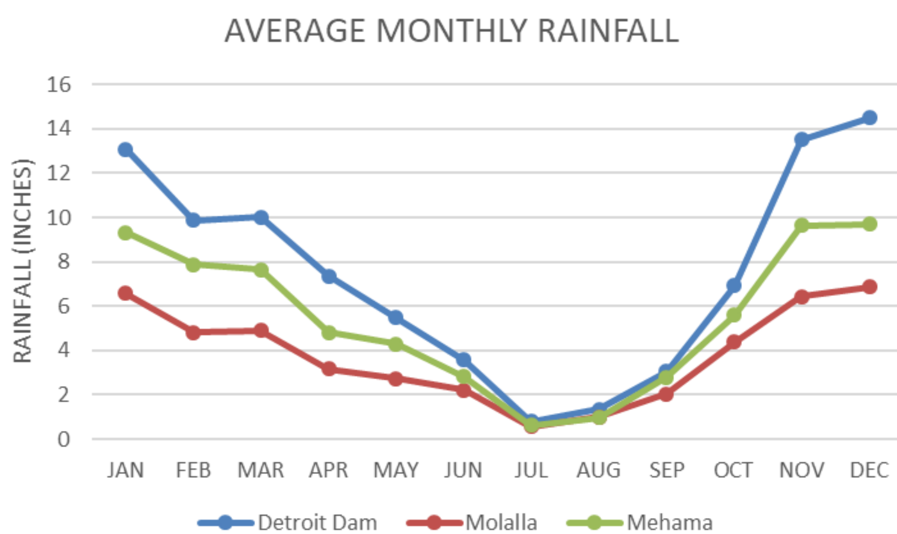


Figure 1: Average monthly rainfall at select locations among burned areas of Beachie Creek Fire (Source: Western Regional Climate Center – www.wrcc.dri.edu)

5.3.3. HYDROLOGY

Peak streamflows are predominately generated by rain-on-snow events in the transient snow zone, which occurs between 1,200 and 4,900 feet elevation (Harr, 1981; Jones and Grant, 1996). Rain-on-snow events are considered the primary effect on peak flows and will vary along elevation bands. The relationship between peak discharge and elevation changes abruptly at around 3,000 feet, due to the fact that snow generally does not accumulate at elevations below 3,000 feet in western Oregon (Cooper, 2005).

Peak discharges on the western slopes of the Cascade Range are typically due to the result of heavy rain from frontal storms falling on snow, frozen ground, or both. Precipitation intensity from frontal storms tends to be low, but storms may last for several days. Where precipitation falls as snow, streamflow is unaffected; however, where precipitation falls as rain, streamflow usually increases rapidly leading to short-duration (i.e. hours) maximum streamflows, then gradually decreasing over several days after the storm front has passed. Generally, maximum streamflows associated with snowmelt runoff are sustained for longer periods of time (i.e. weeks) as weather warms in spring, causing gradual and sustained increases in streamflow due to snowmelt. Furthermore, it is important to note that periods of higher temperatures or rainfall on snow can cause short-duration peaks superimposed over the general trend of long-duration snowmelt peaks. These superimposed peaks will typically lead to the overall peak discharge for the period. Streamflows associated with convective storms rise and decrease rapidly, but maximum flows are not sustained.

There are several periods of elevated flood risk following wildfire, all related to the ability of the soil profile to absorb water. The first high-risk period is the fall immediately post-fire when the lack of vegetation, ground cover, and potentially hydrophobic conditions make the affected area highly susceptible to rapid runoff and erosion from heavy frontal storms.

A second high-risk period occurs in the first spring/summer following the fire when the ground cover and vegetation are just beginning to recover. During this period, soil moisture storage is recharging at a relatively rapid rate since the vegetative water use is significantly reduced, leading to saturated soils. A combination of saturated soils, high rainfall, and rapid snowmelt lead to the floods of December 1964 and February 1996, for example. Finally, the second spring/summer following the wildfire has the potential as a high-risk period for flooding and potential mass erosion. Although the ground and vegetative cover has been re-established, soil moisture storage is at unusually high levels. During periods of reduced soil infiltration capacity of saturated soils in combination with typical weather and climate patterns in these areas, increased surface runoff may lead to elevated peak discharges.

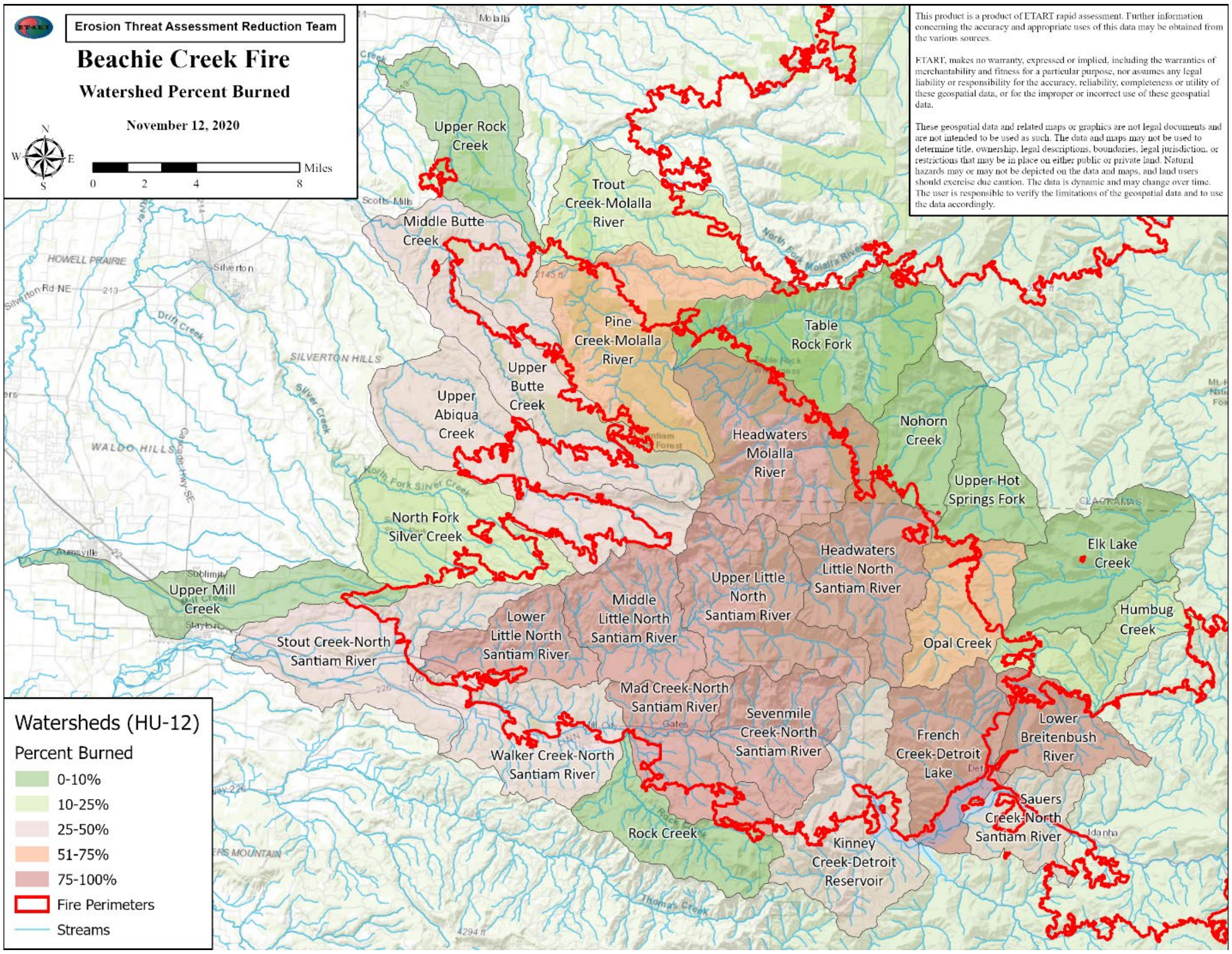


Figure 2: Map of Beachie Creek subwatersheds and percent burned

Little North Santiam Watershed (HUC10: 1709000505)

The Little North Santiam River watershed covers approximately 72,000 acres, with parcels of state-owned land dedicated to the Santiam State Forest. Elevations in the watershed range from 5560 ft. on Battle Axe peak to 600 ft. near its confluence with the North Santiam River. The Little North Santiam River runs west to east from the Opal Creek Wilderness and edge of the Bull of the Woods Wilderness 27 miles to its confluence with the North Santiam River near the small communities of Mehama and Lyons. Water quality has been identified as an issue of concern in the watershed due to high turbidity associated with the high clay content in the drainage, un-regulated flows, and downstream drinking water intakes for the City of Salem (BLM 1997, Sobieszczyk et al, 2004).

Headwaters North Santiam Watershed (HUC10: 1709000501)

The Headwaters North Santiam Watershed includes the Whitewater River that drains from the wilderness area surrounding Mount Jefferson and various smaller drainages that enter the North Santiam above Detroit Reservoir. Elevations within the fire perimeter range from approximately 1,600 feet near Detroit Reservoir to over 8,000 feet on the flanks of Mount Jefferson. Basin-wide mean annual precipitation is approximately 87 inches per year, occurring primarily as snowmelt at higher elevations. This watershed is underlain by High Cascades geology at higher elevations. These younger volcanic deposits (in contrast to the older Western Cascades) are very porous and have high surface and subsurface hydraulic conductivities (Tague and Grant, 2004). Although low intensity, long duration rain falling on a shallow snowpack (i.e. rain-on-snow events) can produce high peak flows and flooding in the spring, these permeable systems lessen the effects of peak discharge.

Upper North Santiam Watershed (HUC10: 1709000503)

The Upper North Santiam watershed consists of small, steep tributaries draining the slopes surrounding Detroit Lake and Big Cliff Reservoir. Burned areas within the watershed are confined to areas on the northern and northeastern sides of the reservoirs. State-owned lands consist of parks and facilities dedicated to the Santiam State Forest and Detroit Lake State Recreation Area, with county parks located throughout the OR-22 corridor. North-South tributary streams, including Sardine Creek, which pass under OR-22, are very susceptible to peak flows occurring during rain-on-snow events. Although the tributaries terminate into the reservoir system, water storage within the small drainages is limited due to the steep and deeply dissected terrain in combination with shallow soils, resulting in flashy flows and steep hydrographic response. These high gradient reaches transport pulses of woody debris and gravelly sediment into the reservoir, as evidenced by deposition at the mouth of the tributaries.

Middle North Santiam Watershed (HUC10: 1709000504)

The Middle North Santiam watershed consists of similarly steep north-south tributary streams seen in the Upper North Santiam Watershed which terminate into the North Santiam River downstream of Big Cliff Dam and Reservoir after passing underneath OR-22. Much of the burned areas are confined to the steep northern slopes of the watershed, as well as a significant portion of the Sevenmile Creek tributary; however, much of Rock Creek, the largest tributary of the Middle North Santiam Watershed which supplements flow, remained unburned.

Lower North Santiam Watershed (HUC10: 1709000506)

Small portions of the Lower North Santiam Watershed were burned just below the confluence of the North Santiam and Little North Fork Santiam Rivers near the communities of Lyons and Mehama. Stream valleys in this region widen as gradients gradually decrease. Tributary streams in this region are susceptible to rain-on-snow events. At this point, main stem streamflow of the North Santiam River is influenced by dam operations such that peak flows associated with heavy rainfall and/or rapid snowmelt, such as springtime peaks, are dampened (Snyder et al, 2002).

Upper Molalla Watershed (HUC10: 1709000904)

The headwaters of the Upper Molalla begin in the forested lower west slopes of the Cascade Range at elevations near 4,800 feet. The stream gradient is mild with an average of 1.2 percent in the upper portion of the watershed with a varying width, flowing over boulders in narrow gorges and wider riffles. Geologic hazards associated with slope failures exist in the steep, mountainous terrain of the headwaters and can deliver large quantities of unconsolidated materials to drainage ways, and increase sediment loads and cause higher turbidities (BLM, 1999).

Table 1: Burn statistics of watersheds (HUC10) impacted by Beachie Creek and Lionshead Fires.

HUC10	Watershed Name	Acres	Acres Burned	% of Watershed Burned
Beachie Creek				
1709000501	Breitenbush River	69,326	1,564	2.3%
1709000502	Headwaters North Santiam River	146,501	45	<0.1%
1709000503	Upper North Santiam River	71,406	21,892	30.7%
1709000504	Middle North Santiam River	56,684	30,283	53.4%
1709000505	Little North Santiam River	72,405	68,103	94.1%
1709000506	Lower North Santiam River	72,785	5,866	8.1%
1709000702	Mill Creek	71,870	686	1.0%
1709000901	Abiqua Creek-Pudding River	179,192	11,212	6.3%
1709000902	Butte Creek-Pudding River	70,441	13,957	19.8%
1709000903	Rock Creek	54,819	47	0.1%
1709000904	Upper Molalla River	129,537	38,588	29.8%
1709001101	Collawash River	97,472	606	0.6%
Lionshead				
1707030109	Upper Metolius River	140,908	7,904	5.6%
1707030110	Lower Metolius River	145,823	21,813	15.0%
1707030603	Shitike Creek-Deschutes River	145,099	16,013	11.0%
1707030604	Mill Creek	69,089	40,396	58.5%
1707030606	Warm Springs River	170,551	10,636	6.2%
1709000501	Breitenbush River	69,326	53,884	77.7%
1709000502	Headwaters North Santiam River	146,501	38,190	26.1%
1709000503	Upper North Santiam River	71,406	3,096	4.3%
1709001101	Collawash River	97,472	1,389	1.4%
1709001102	Upper Clackamas River	100,947	11,153	11.0%

5.4. Assessment Methodology and Modeling

Team members drove public roads near rivers and stopped to assess conditions predominantly at publicly-owned facilities, including sites for which we had advance notice to assess risk (e.g., City of Molalla water intake). We used a combination of indicators we could see and best professional judgment to assess these risks. These indicators included:

- Level of moss on rocks and vegetation type and elevation to indicate flood return intervals of e.g., less than 5 years
- Channel form (e.g., incised canyons) to assess potential flood heights
- Portion of upslope area with different percentages of burn severity
- Existence of hazard trees onsite and along upstream channels

Post-fire watershed response for the Beachie Creek Fire was conducted in order to determine the impact of soil burn severity on the response of modeled peak flows in drainages with values identified as 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.

5.5. 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 Little North Fork Santiam watershed where over 94% of the watershed has burned (). The Little North Fork Santiam River at Salmon Falls has a predicted increase in peak flow from 8,690 cfs to 12,665 cfs at the 5-year recurrence interval, an increase of 1.6 times the pre-fire peak flow magnitude. The elevated peak flow response is due to the large portion of moderate or high soil burn severity in a relatively smaller watershed. In contrast, the greatest increase in magnitude of post-fire peak flows in any other subwatershed is 1.2 times the pre-fire peak flow for the 5-year recurrence interval.

For areas within the Middle North Santiam River watershed, the regional regression equations do not factor in alterations to hydrology due to Detroit Lake and Big Cliff Reservoir operations. The largest tributary within this watershed, Rock Creek, remained largely unburned. Burned areas within the watershed include smaller tributaries such as Mad Creek and Sevenmile Creek, as well as the smaller, steep northern slopes draining into the middle portion of the North Santiam River. Although the magnitude of peak flows for streams within burned areas are projected to increase, the North Santiam River below Detroit Lake and Big Cliff Reservoir are designed to handle scheduled releases of much greater magnitude. Risk associated with burned areas downstream of the reservoir system in the Middle North Santiam River watershed are likely to be minimal along the main stem of the North Santiam River.

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 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.

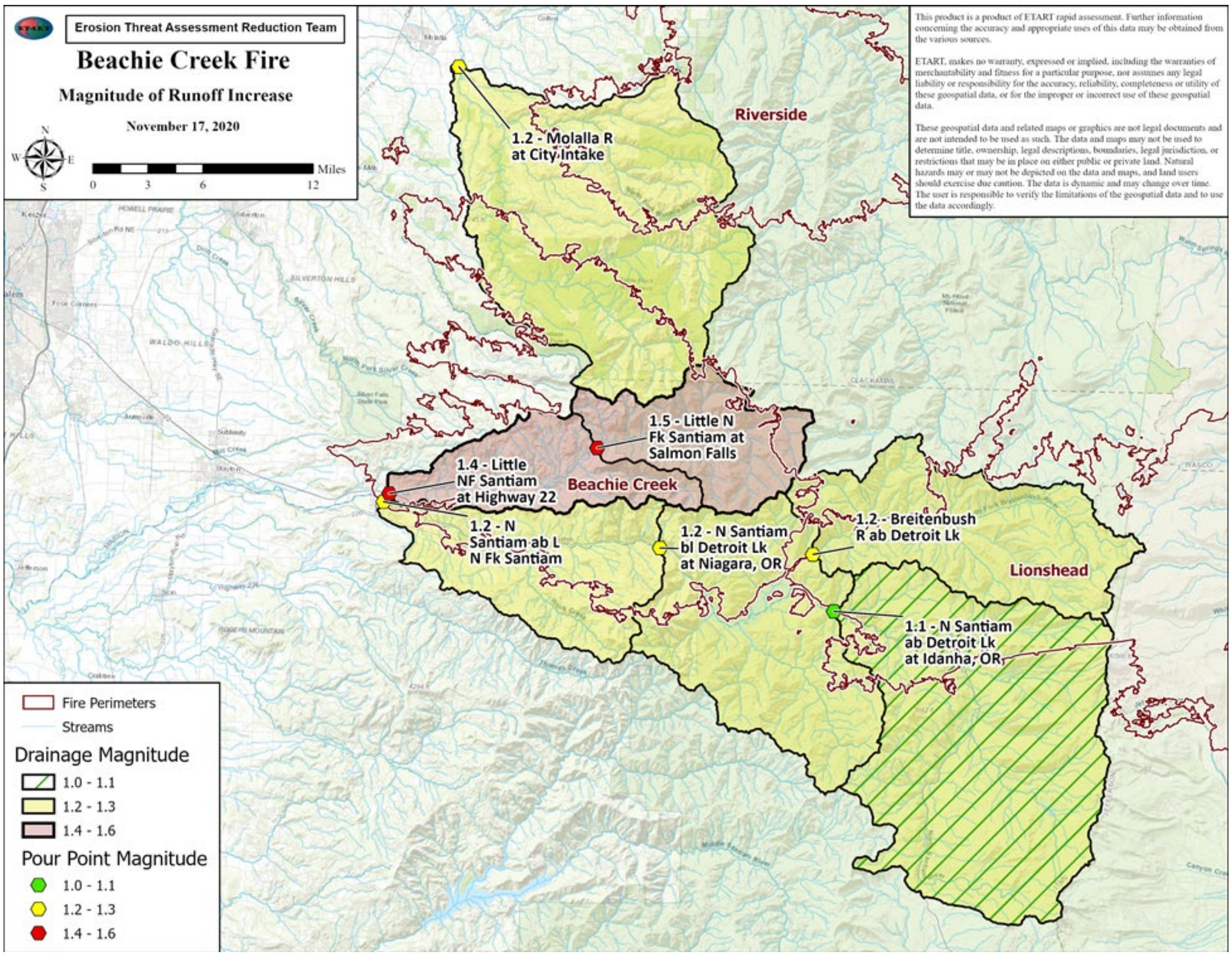


Figure 3: Map of Beachie Creek and Lionshead fire areas and streamflow response for select poursheds for 5-year return interval storms. For ease of display, the pourpoint for the North Santiam just below the confluence with the Little North Santiam is omitted, but it has a drainage magnitude of 1.2-1.3.

Figure 4: Pre- and post-fire peak discharge at select poursheds.

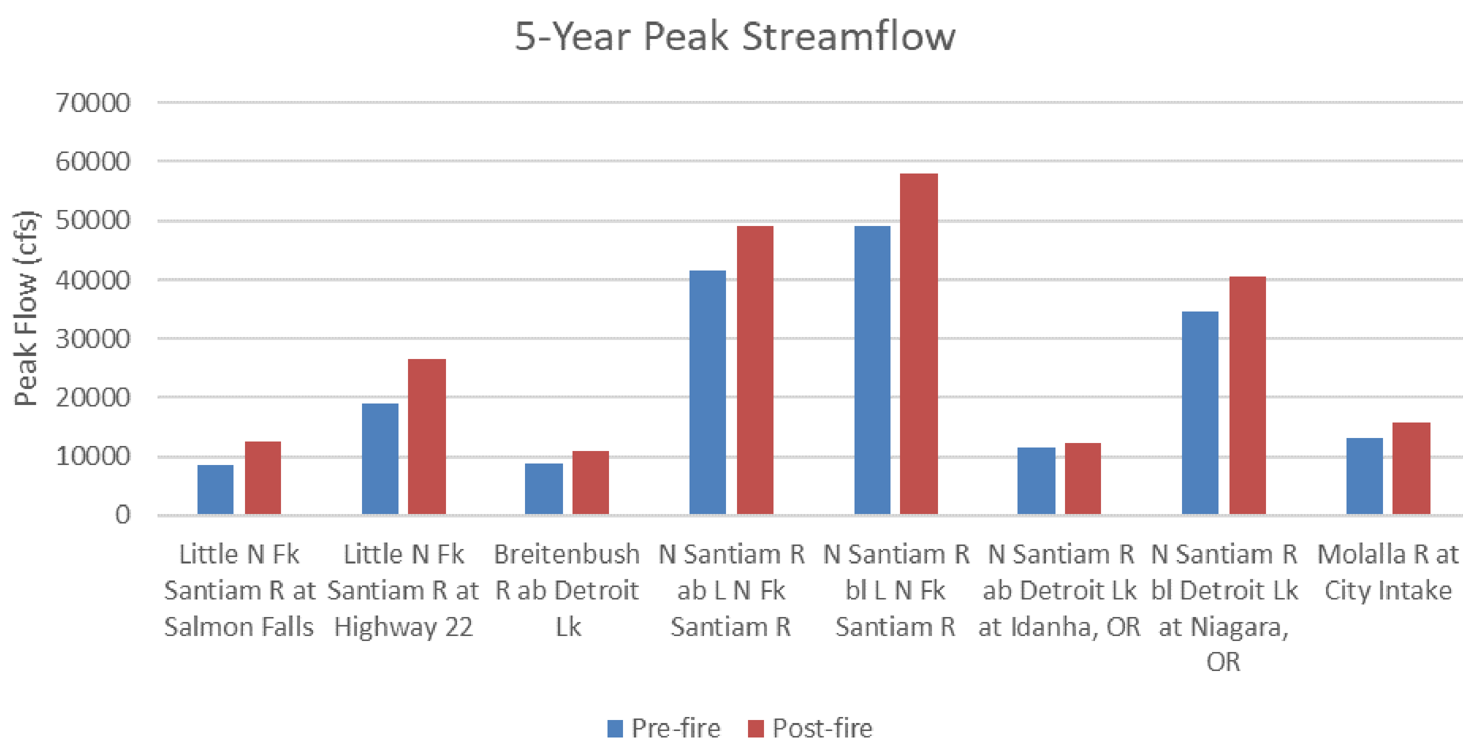


Table 2: Modeling results for post-fire increase in watershed peak flows.

			Peak Streamflows (cfs)					Magnitude Increase	
PourShed	**Drainage Area (sq mi)**	**% Mod + High Burn Severity**	**Pre-fire 2-year**	**Pre-fire 5-year**	**Pre-fire 10-year**	**Post-fire 2-year**	**Post-fire 5-year**	**2-year**	**5-year**
Little N Fk Santiam at Salmon Falls	58	73.3	5,930	8,690	10,600	9,310	12,665	1.6	1.5
Little N Fk Santiam R at Highway 22	113	73.0	13,400	19,000	22,800	20,327	26,647	1.5	1.4
Breitenbush R ab Detroit Lk	105	39.3	6,180	8,850	10,700	8,481	11,055	1.4	1.2
N Santiam ab L N Fk Santiam	540	21.3	25,500	41,500	53,400	33,069	48,995	1.3	1.2
N Santiam bl L N Fk Santiam	654	30.1	34,200	49,100	59,500	43,129	57,930	1.3	1.2
N Santiam ab Detroit Lk at Idanha, OR	215	9.0	7,540	11,500	14,500	8,459	12,351	1.1	1.1
N Santiam bl Detroit Lk at Niagara, OR	452	20.1	21,300	34,600	44,600	27,273	40,566	1.3	1.2
Molalla R at City Intake	203	30.6	8,880	13,200	16,400	11,598	15,913	1.3	1.2

5.5.1. RISK ASSESSMENT

The predominant high risk at assessed sites (including but not limited to boat launches at Detroit Lake, the North Santiam and Little North Fork Santiam, the park next to Salmon Falls, Bear Creek County Campground, Packsaddle Park, North Santiam State Recreation Area) were from hazard trees potentially falling, and thereby destroying property or killing or grotesquely maiming people. Similarly, downed trees pose a significant life to human safety and life when boating (including but not limited to the North Santiam and Little North Fork Santiam, and Detroit Lake). The final major risk is clogging of water intakes (including City of Molalla) from increased loading of sediment and large wood. The Detroit Lake State Recreation area has a damaged water intake and holding tank. For more information on these risks, see the Values at Risk table in Appendix G.

5.6. Recommendations

Regarding hazard trees, the main recommendations are to ensure exclusion of 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 warning boaters of the risks posed by large wood. Large wood in reservoirs can more easily be treated by removing it, but signage is also important to warn boaters of the risks. For protection of water intakes, the primary treatment is to increase frequency of inspection and debris removal, and outreach to the public on water usage should the increased loading of sediment and debris require a temporary shutdown. For the drinking water infrastructure at Detroit Lake State Recreation Area, replace damaged infrastructure and clear outlet prior to and after storms.

5.6.1. RECOMMENDED MONITORING

Modeling suggests that some watersheds affected by the Beachie 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. A 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.

Many gaging stations are present in watersheds within and adjacent to the burned areas of the Beachie Creek and Lionshead Fires 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).

5.7. References

Bureau of Land Management. 1997. Little North Santiam Watershed Analysis.

Bureau of Land Management. 1999. Molalla Watershed Analysis.

Burned Area Emergency Response (BAER) Plan, Beachie Creek and Riverside Fires: Watershed Resources Assessment. October 2020.

Cooper, R.M. 2005. Estimation of Peak Discharges for Rural, Unregulated Streams in Western Oregon. U.S. Geological Survey Scientific Investigations Report 2005-5116, 134 p.

Harr, R. D. 1981. Some Characteristics and Consequences of Snowmelt During Rainfall in Western Oregon. Journal of Hydrology, 53(3-4), 277-304.

Hydrology Resource Report, Beachie and Lionshead Fire BAER Assessment: Willamette, Mt. Hood, and Deschutes National Forests. October 2020.

Jones, J.A., and Grant, G.E. 1996. Peak Flow Responses to Clear-Cutting and Roads in Small and Large Basins, Western Cascades, Oregon. Water Resources Research, 32(4), 959-974.

Moody, J.A., and Martin, D.A. 2001. Post-Fire, Rainfall Intensity – Peak Discharge Relations for Three Mountainous Watersheds in the Western USA. Hydrological Processes, 15, 2981-2993.

Sobieszczyk, S., Uhrich, M.A., and Bragg, H.M. 2007. Major Turbidity Events in the North Santiam River Basin, Oregon, Water Years 1999-2004: U.S. Geological Survey Scientific Investigations Report 2007-5178, 50 p.

Snyder, K.U., Sullivan, J.T., Raymond, R.B., Moore, D., and Gilbert, E. 2002. North Santiam River Watershed Assessment. E&S Environmental Chemistry, Inc. Corvallis, OR.

Tague, C., and Grant, G.E. 2004. A Geological Framework for Interpreting the Low-Flow Regimes of Cascade Streams, Willamette River Basin, Oregon. Water Resources Research, 40, W04303.

USDA Forest Service. 2009. USGS Regression methods, https://forest.moscowfsl.wsu.edu/BAERTOOLS/ROADTRT/Peakflow/USGS

6. Geologic Hazards

Barton Wills – Geologist, U.S. Forest Service
Bill Burns – Engineering Geologist, Oregon Department of Geology and Mineral Industries
Brandon Overstreet – Geomorphologist, U.S. Geological Survey

6.1. Introduction

This report is a rapid post-wildfire geologic hazards assessment of the non-USFS portions of the Beachie 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 historical 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 Beachie Creek Fire began August 16, 2020, at 11:15 am approximately two miles south of Jawbone Flats on the Willamette National Forest. An historic windstorm on Monday, September 7, caused rapid spread west through the Willamette and Mt. Hood National Forests, and adjacent private lands and communities. The Beachie Creek Fire heavily impacted several communities in the North Santiam River and Little North River drainages including Jawbone Flats, Elkhorn, Gates, Mill City, Lyons, Mehama, and portions of the Detroit Lake community. The fire (as of 10/12/2020) encompassed 193,631 acres.

The USFS assembled a Burned Area Emergency Response (BAER) team on September 28, 2020. 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. 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. On October 26, 2020, the Oregon Erosion Threat Assessment and Response Team (ETART) was formed to make assessments of state, county, and private lands and property.

6.1.1. RAPID ASSESSMENT OBJECTIVES

When evaluating Geologic Hazards, the objectives of the "Geology" specialty group on a ETART Team is identifying the geologic conditions and geomorphic processes that have helped shape and alter the watersheds and landscapes, and assessing the impacts from the fire on those conditions and processes that could affect downstream assets/critical values. The fire removed vegetation which keep 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 impacted 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

Major drainages in the burned area include portions of the Little North Santiam River, North Santiam River, Cedar Creek, Elkhorn Creek, Opal Creek, and French Creek. Elevations in the burn area range from about 900 feet above sea level at the west end of the fire to the summit of Mount Beachie at 5,200 feet above sea level at the east end of the fire.

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 different frequencies of movements, triggering conditions, and very different resulting hazards. In the Cascades, debris flows and related flash flooding/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, colluvium-filled hollows or in a drainage in the upper portions of a basin. As the landslide moves down the channel or transports, 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 centration 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 very 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 future 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, Google Earth, USGS emergency assessments of post-fire debris-flow hazards, Statewide Landslide Information Database of Oregon (SLIDO), and orthoimagery.

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) (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 approximate information for warning systems but should be considered alongside hydrologic modeling and local knowledge.

SLIDO is 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 is unlikely to be an immediate post-fire concern directly pertinent to ETART.

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 (Section II) to this report. Below is a short list of the primary high-risk assets/critical values:

Communities of Idanha and Detroit – The community of Idanha is partially built on large deep landslide deposits. Portions of the City of Detroit are located below channels identified by the USGS as moderate and high potential for debris flows (Appendix D, Figure 2, Photos 1A & 1B). 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.

Oregon State Route 22 - 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 indicate that they are currently addressing rockfall and are planning for potential debris flows to the highway corridor (Appendix D, Figures 1, 2, 3 & 4).

Big Cliff Dam – The Big Cliff Dam and facilities are located directly below channels identified by the USGS as moderate and high potential for debris flows. Further hazard evaluation is recommended to protect the facility (Appendix D, Figure 3, Photos 2A & 2B).

Mehama, Mill City, Gates, Niagara Communities – Portions of these communities are built on deep landslide deposits that could reactivate post fire. Portions of these communities are located 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 D, Figure 4 (Niagara)).

Little North Santiam/Elkhorn – The Little North Santiam has a combination of landslide and debris flow hazards. In the lower section of the valley, small shallow landslides and large deep landslides are common. Some of these existing landslides are active and therefore, the post-fire landscape may lead to continued activity. Several communities including the City of Salem rely on drinking water from this watershed and should be prepared for landslides and debris flows to contribute sediment and possibly damage portions of their systems depending on locations. Above Salmon Falls, the debris flow hazard generally increases and some private residences, power lines and power line access are generally at risk from landslides (Appendix D, Figure 5 and Photos 4 & 5).

During the ground survey reconnaissance, 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. State and county roads, private access roads, power lines, pipelines and water systems should be evaluated for debris flows, rockfall, and flash flooding which could cause damage to these systems.

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 the Beachie 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 Beachie 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 but rarely lives.

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.

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 is to help residents and landowners in the fire area become aware of the role they can play in readiness for hazardous events and risk reduction.

At many sites, we recommend signs are locally placed 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, Photo 6).

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

- https://www.oregongeology.org/Landslide/ger_homeowners_guide_landslides.pdf

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.

6.6. References

Beaulieu, JD, Hughes, PW; and Mathiot, RK, 1974, Environmental geology of western Linn County, Oregon, Oregon Dept. of Geology and Mineral Industries, Bulletin 84, 1:62,500

Burns, W.J., Mickelson, K.A., and Madin, I.P., 2016, Landslide Susceptibly Overview Map of Oregon, Oregon Department of Geology and Mineral Industries, Open File Report O-16-02

Calhoun, N., Madin, I., and Appleby, C, 2020, Landslide Inventory for a Portion of Marion County, Oregon, Oregon Department of Geology and Mineral Industries, Open File Report O-20-12

Conrey, RM, 1991, Geology and petrology of the Mt. Jefferson area, High Cascade Range, Oregon, Washington State University, Dissertation, 1:62,500

DOGAMI, 2020, Statewide Landslide Information Database for Oregon (SLIDO), Oregon Department of Geology and Mineral Industries, updated October 2020, https://www.oregongeology.org/slido/index.htm

Hammond, PE, Geyer, KM; and Anderson, JL, 1982, Preliminary geologic map and cross sections of the Upper Clackamas and North Santiam Rivers area, northern Oregon Cascade Range, Portland State University, 1:62,500

Jackson, JS, 1978, Geologic map of the Bull of The Woods area, Oregon, Portland State University, Thesis, 1:24,000

Kean, J.W., McCoy, S.W., Tucker, G.E., Staley, D.M., Coe, J.A., 2013, Runoff-generated debris flows: Observations and modeling of surge initiation, magnitude, and frequency, Journal of Geophysical Research Earth Surface, 118(4), p. 2190-2207.

Miller, PR and Orr, WN, 1984, Geologic map of the Wilhoit quadrangle, Oregon, Oregon Dept. of Geology and Mineral Industries, Geological Map Series GMS-32, 1:24,000

O'Connor, JE, Sarna-Wojcicki, A; Wozniak, KC; Polette, DJ; and Fleck, RJ, 2001, Geologic map of Quaternary Units in the Willamette Valley, Oregon, U.S. Geological Survey, Professional Paper 1620, 1:250,000

ODOT, 2014, Hydraulics Design Manual, Oregon Department of Transportation Highway Division, Chapter 7, Appendix A, Rainfall-Intensity-Duration-Recurrence Interval Curves, Zone 5

O'Loughlin, C.; Ziemer, R. R. 1982. The importance of root strength and deterioration rates upon edaphic stability in steepland forests. Proceedings of I.U.F.R.O. Workshop P.1.07-00 Ecology of Subalpine Ecosystems as a Key to Management. 2-3 August 1982, Corvallis, Oregon. Oregon State University, Corvallis, Oregon. p. 70-78.

Olson, JP, 1978, Geologic map of the North Santiam Mining District, Marion County, Oregon, Oregon State University, Thesis, 1:62,500

Orr, WN and Miller, PR, Geologic map of the Elk Prairie Quadrangle, Marion County, Oregon, Oregon Dept. of Geology and Mineral Industries, Geological Map Series GMS-51, 1:24,000

Personius, S.F., compiler, 2002, Fault number 864, Clackamas River fault zone, in Quaternary fault and fold database of the United States: U.S. Geological Survey website, https://earthquakes.usgs.gov/hazards/qfaults, accessed 10/11/2020 02:44 PM

Priest, GR, Woller, NM; and Ferns, ML, 1987, Geologic map of the Breitenbush River area, Linn and Marion Counties, Oregon, Oregon Dept. of Geology and Mineral Industries, Geological Map Series GMS-46, 1:62,500

Pungrassami, T, 1969, Geologic map and section of the Western Detroit Reservoir Area, Quartzville and Detroit Quadrangles, Linn and Marion Counties, Oregon, Oregon State University, Thesis, 1:24,000

Roering, JJ, et al, 2003, Shallow landsliding, root reinforcement, and the special distribution of trees in the Oregon Coast Range, Canadian Geotechnical Journal

Scott, WE, 1977, Quaternary glaciation and volcanism, Metolius River area, Oregon, University of Washington, Professional Paper, 1:62,500

Shank, D., 2013, Short Creek Turbidity, internal Forest Service letter, unpublished

Sherrod, DR, 1988, Geology and geothermal resources of the Breitenbush-Austen Hot Springs area, Clackamas and Marion Counties, Oregon, Oregon Dept. of Geology and Mineral Industries, Open File Report O-88-5, 1:24,000

Sherrod, DR and Smith, JG, 2000, Geologic map of Upper Eocene to Holocene Volcanic and Related Rocks of the Cascade Range, Oregon, U.S. Geological Survey, Interpretive Map I-2569, 1:500,000

Staley DM, Kean JW, Cannon SH, Schmidt KM, Laber JL, 2013, Objective definition of Rain-fall intensity–duration thresholds for the initiation of post-fire debris flows in Southern California. Landslides 10:547–562

Staley, D.M., Negri, J.A., Kean, J.W., Tillery, A.C., Youberg, A.M., 2016, Updated logistic regression equations for the calculation of post-fire debris-flow likelihood in the western

Staley, D.M., Negri, J.A., Kean, J.W., Tillery, A.C., Youberg, A.M., 2016, Updated logistic regression equations for the calculation of post-fire debris-flow likelihood in the western United States: U.S. Geological Survey Open-File Report 2016-1106, 20 p., available at https://pubs.er.usgs.gov/publication/ofr20161106

Staley, D.M., Negri, J.A., Kean, J.W., Tillery, A.C., Youberg, A.M., 2016, Updated logistic regression equations for the calculation of post-fire debris-flow likelihood in the western United States: U.S. Geological Survey Open-File Report 2016-XXXX, 20 p., available at http:// pubs.usgs.gov/of/2016/XXXX/

Staley DM, Negri JA, Kean JW, Laber JL, Tillery AC, Youberg AM (2017) Prediction of spatially explicit rainfall intensity–duration thresholds for post-fire debris-flow generation in the Western United States. Geomorphology 278:149–162

Walker, GW and Duncan, RA, 1989, Geologic map of the Salem 1 by 2 degree quadrangle, Western Oregon, U.S. Geological Survey, Miscellaneous Investigations Map I-1893, 1:250,000

Walker, GW and MacLeod, NS, 1991, Spatial digital database for the geologic map of Oregon, U.S. Geological Survey, Open File Report 03-67, 1:500,000

Wall, S.A., Roering, J.J. & Rengers, F.K. Runoff-initiated post-fire debris flow Western Cascades, Oregon. Landslides 17, 1649–1661 (2020). https://doi.org/10.1007/s10346-020-01376-9

White, CM, 1980, Geology of the Breitenbush Hot Springs quadrangle, Oregon, Oregon Dept. of Geology and Mineral Industries, 1:62,500, Special Paper 9

White, CM, 1980, Geology of the Breitenbush Hot Springs quadrangle, Oregon, Oregon Dept. of Geology and Mineral Industries, 1:62,500, Special Paper 9

Wiley, T.J., 2000, Relationship between rainfall and debris flows in western Oregon, Oregon Geology, Volume 62, Number 20, Department of Geology and Mineral Industries

Yeats, RS, Graven, EP; Werner, KS; Goldfinger, C; and Popowski, TA, 1996, Geologic map of the Central and Southern Willamette Valley, Benton, Lane, Linn, Marion, and Polk Counties, Oregon, U.S. Geological Survey, Professional Paper 1560, Plate 2B, 1:100,000

Yeats, RS, Werner, KS; and Popowski, TA, 1996, Geologic map of the Northern Willamette Valley, Clackamas, Marion, Multnomah, Polk, Tillamook, Washington, and Yamhill Counties, Oregon, U.S. Geological Survey, Professional Paper 1560, Plate 2A, 1:100,000

Yogodzinski, GM, 1985, The Deschutes Formation - High Cascades transition in the Whitewater River area, Jefferson County, Oregon, 1:24,000, Oregon State University, Thesis

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 Beachie 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 Beachie 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 Beachie 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 Beachie 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
Beachie Creek	BLM	58	61	62	67	249	191
	County	4	11	13	10	38	34
	Local Government	0	0	0	0	0	0
	ODF	74	40	36	42	192	118
	Other	1	0	0	1	2	1
	Port Blakely	5	5	4	5	20	15
	Private (Unspecified)	0.2	2	4	9	15	15
	Private Industrial	76	64	66	163	369	293
	Private Non-industrial	30	44	43	48	165	135
	State	0	0.2	0.2	0	0.5	0.4
	State Parks	1	0.4	0.2	0.1	2	0.7
	USACE	0	0.3	0.6	0.2	1	1
	Weyco	24	25	27	64	139	115
Beachie Creek Total		**273**	**253**	**257**	**409**	**1193**	**919**

There are nearly 220 miles of roads with moderate to high levels of basal area mortality on state, county and non-industrial private land (including unspecified private), with another 100+ 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”.

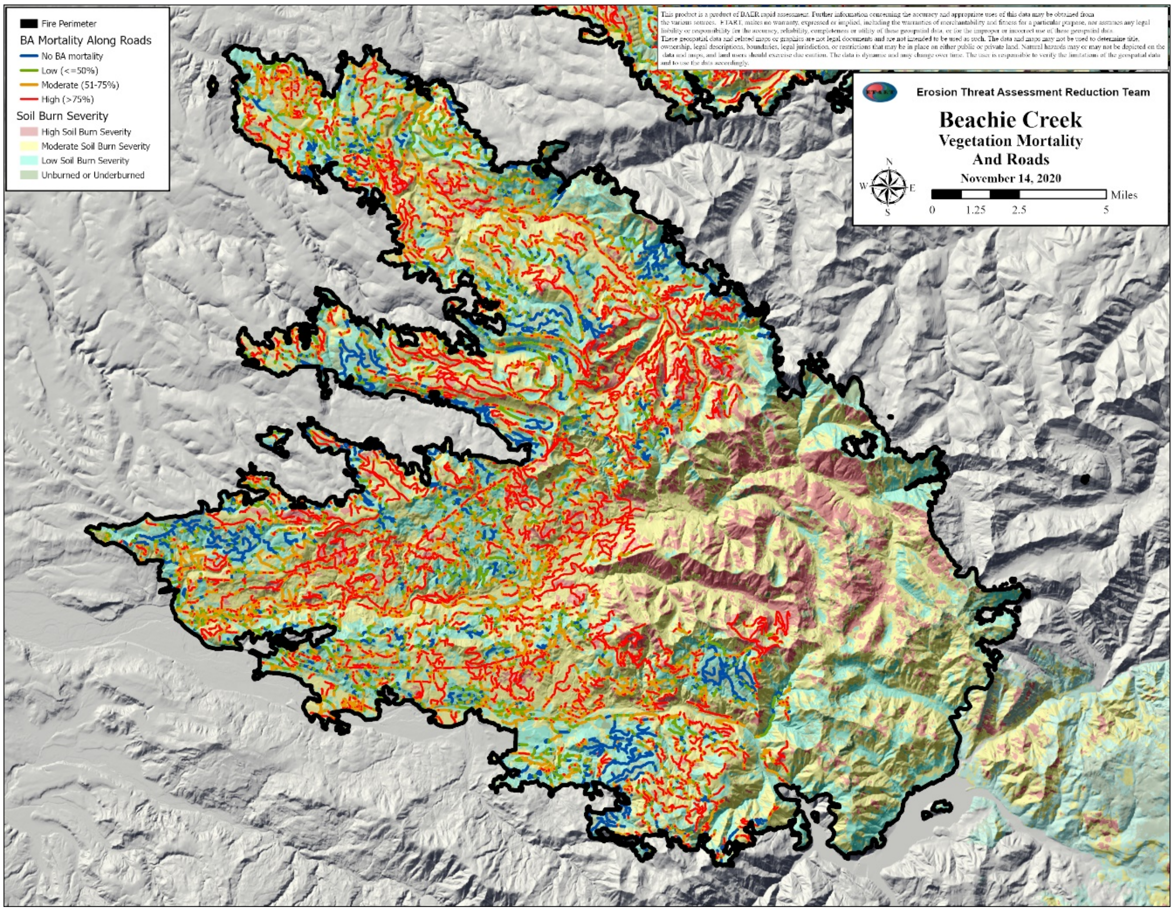


Figure 1. Roads mapped by percent basal area mortality within the Beachie Creek Fire perimeter.

7.2.2. STRUCTURES ANALYSIS

- Acres within a 100’ buffer surrounding all structures within the Beachie 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**
Beachie Creek	295	415	579	746	419	544	217	200	1214	1490

There are 744 structures located in areas that suffered 50% or greater basal area mortality (Fig. 2). Another 746 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 1200 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.

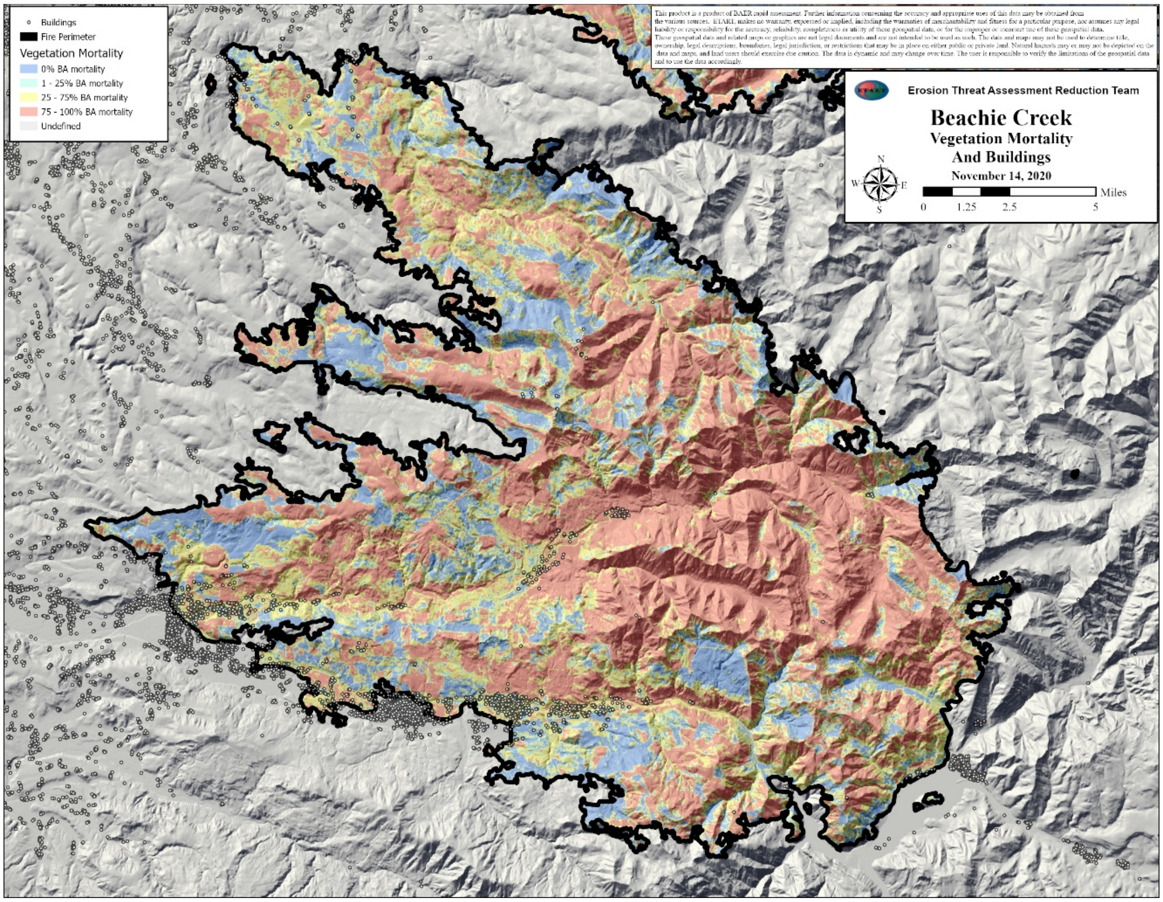


Figure 2. Location of structures within the Beachie Creek Fire perimeter and their locations relative to vegetation mortality.

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

Authors: I. Blakey Lockman- Regional Forest Pathologist, USDA Forest Service, PNW Region, State and Private Forestry; Kristen Chadwick- Forest Pathologist, USDA Forest Service, PNW Region, State and Private Forestry; Sharon Hood- Research Ecologist, USDA Forest Service, Rocky Mountain Research Station, Fire Sciences Lab; and Iral Ragenovich- Regional Entomologist, USDA Forest Service, PNW Region, State and Private Forestry.

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.

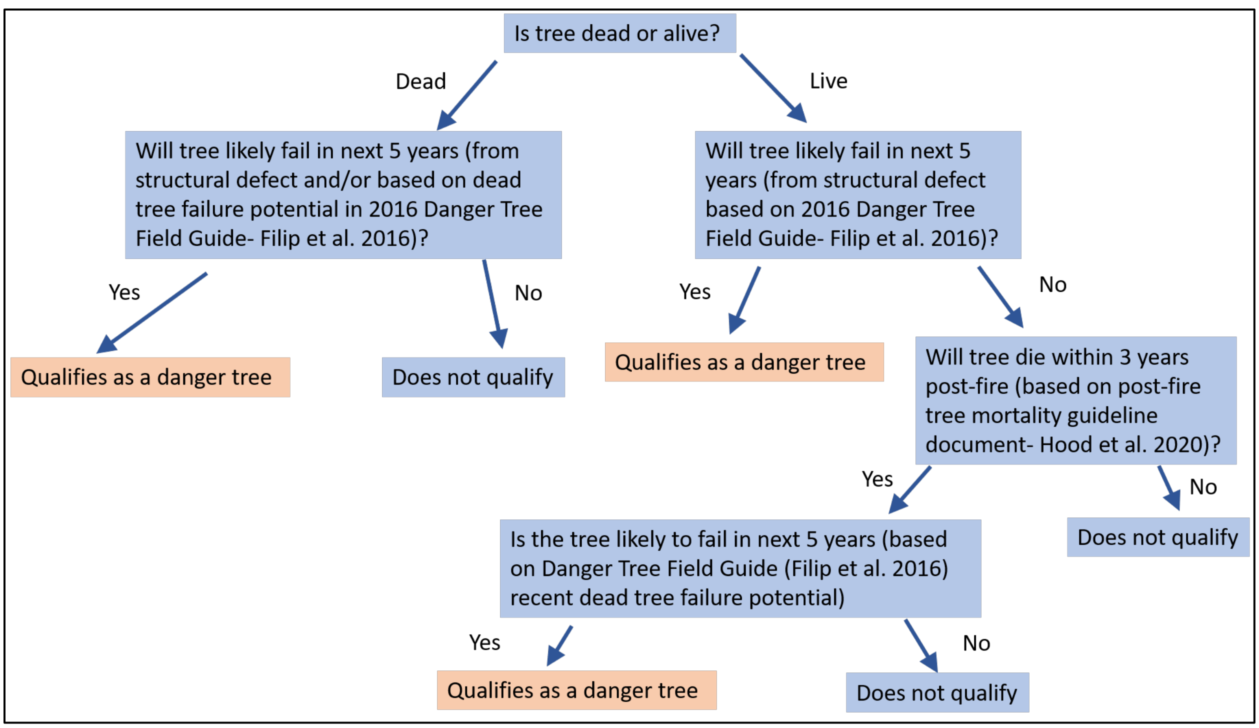


Figure 3. Decision tree for determination of danger trees after wildfire

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. DF, pine, cedar, juniper or larch with >75% of bole cross-section burned & consumed. Any species with >1 quadrant burned & consumed structural roots.	True fir, hemlock, spruce or hardwood with 25-50% of bole cross-section burned & consumed. DF, pine, cedar, juniper or larch with 50-75% of bole cross-section burned & consumed, Any species with 1 quadrant burned & consumed structural roots.	True fir, hemlock, spruce or hardwood with <25% of bole cross-section burned & consumed. DF, pine, cedar, juniper or larch with <50% of bole cross-section burned & consumed, 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 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): • > 85% needles scorched OR • > 40% needles consumed/blackened OR • > 5% and ≤ 40% needles consumed/blackened combined with >50% needles scorched 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.

7.5. References

Cansler, C. A., S. M. Hood, J. M. Varner, P. J. van Mantgem, M. C. Agne, R. A. Andrus, M. P. Ayres, B. D. Ayres, J. D. Bakker, M. A. Battaglia, B. J. Bentz, C. R. Breece, J. K. Brown, D. R. Cluck, T. W. Coleman, R. G. Corace, W. W. Covington, D. S. Cram, J. B. Cronan, J. E. Crouse, A. J. Das, R. S. Davis, D. M. Dickinson, S. A. Fitzgerald, P. Z. Fulé, L. M. Ganio, L. M. Grayson, C. B. Halpern, J. L. Hanula, B. J. Harvey, J. Kevin Hiers, D. W. Huffman, M. Keifer, T. L. Keyser, L. N. Kobziar, T. E. Kolb, C. A. Kolden, K. E. Kopper, J. R. Kreitler, J. K. Kreye, A. M. Latimer, A. P. Lerch, M. J. Lombardero, V. L. McDaniel, C. W. McHugh, J. D. McMillin, J. J. Moghaddas, J. J. O'Brien, D. D. B. Perrakis, D. W. Peterson, S. J. Prichard, R. A. Progar, K. F. Raffa, E. D. Reinhardt, J. C. Restaino, J. P. Roccaforte, B. M. Rogers, K. C. Ryan, H. D. Safford, A. E. Santoro, T. M. Shearman, A. M. Shumate, C. H. Sieg, S. L. Smith, R. J. Smith, N. L. Stephenson, M. Stuever, J. T. Stevens, M. T. Stoddard, W. G. Thies, N. M. Vaillant, S. A. Weiss, D. J. Westlind, T. J. Woolley, and M. C. Wright. 2020a. The Fire and Tree Mortality Database, for empirical modeling of individual tree mortality after fire. Scientific Data **7**:194.

Cansler, C. A., S. M. Hood, J. M. Varner, P. J. van Mantgem, M. C. Agne, R. A. Andrus, M. P. Ayres, B. D. Ayres, J. D. Bakker, M. A. Battaglia, B. J. Bentz, C. R. Breece, J. K. Brown, D. R. Cluck, T. W. Coleman, R. G. Corace, W. W. Covington, D. S. Cram, J. B. Cronan, J. E. Crouse, A. J. Das, R. S. Davis, D. M. Dickinson, S. A. Fitzgerald, P. Z. Fulé, L. M. Ganio, L. M. Grayson, C. B. Halpern, J. L. Hanula, B. J. Harvey, J. K. Hiers, D. W. Huffman, M. Keifer, T. L. Keyser, L. N. Kobziar, T. E. Kolb, C. A. Kolden, K. E. Kopper, J. R. Kreitler, J. K. Kreye, A. M. Latimer, A. P. Lerch, M. J. Lombardero, V. L. McDaniel, C. W. McHugh, J. D. McMillin, J. J. Moghaddas, J. J. O'Brien, D. D. B. Perrakis, D. W. Peterson, S. J. Prichard, R. A. Progar, K. F. Raffa, E. D. Reinhardt, J. C. Restaino, J. P. Roccaforte, B. M. Rogers, K. C. Ryan, H. D. Safford, A. E. Santoro, T. M. Shearman, A. M. Shumate, C. H. Sieg, S. L. Smith, R. J. Smith, N. L. Stephenson, M. Steuver, J. T. Stevens, M. T. Stoddard, W. G. Thies, N. M. Vaillant, S. A. Weiss, D. J. Westlind, T. J. Woolley, and M. Wright. 2020b. Fire and tree mortality database (FTM). Fort Collins, CO: Forest Service Research Data Archive. Updated 24 July 2020. https://doi.org/10.2737/RDS-2020-000.

Cansler, C. A., S. M. Hood, P. J. van Mantgem, and J. M. Varner. 2020c. A large database supports the use of simple models of post-fire tree mortality for thick-barked conifers, with less support for other species. Fire Ecology **16**:25.

Davis, R. S., S. Hood, and B. J. Bentz. 2012. Fire-injured ponderosa pine provide a pulsed resource for bark beetles. Canadian Journal of Forest Research **42**:2022-2036.

Filip, G., M. Barger, J. Bronson, K. Chadwick, R. Collins, B. Goodrich, H. Kearns, M. McWilliams, B. Oblinger, D. Omdal, A. Ramsey, and A. Saaverdra. 2016. Danger-Tree Identification and Response along Forest Roads and Work Sites in Oregon and Washington. R6-NR-TP-021-2016. http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fseprd512960.pdf.

Filip, G., J. Biro, K. Chadwick, D. Goheen, E. Goheen, J. Hadfield, A. Kanaskie, H. Kearns, H. Maffei, K. Mallams, D. Omdal, A. Saavedra, and C. Schmitt. 2014. Field Guide for Hazard-Tree Identification and Mitigation on Developed Sites in Oregon and Washington Forests. R6-NR-TP-021-2013. https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprd3799993.pdf .

Filip, G. M., C. L. Schmitt, D. W. Scott, and S. A. Fitzgerald. 2007. Understanding and defining mortality in western conifer forests. Western Journal of Applied Forestry **22**:105-115.

Fowler, J. F., C. H. Sieg, J. McMillin, K. K. Allen, J. F. Negron, L. L. Wadleigh, J. A. Anhold, and K. E. Gibson. 2010. Development of post-fire crown damage mortality thresholds in ponderosa pine. International Journal of Wildland Fire **19**:583-588.

Goheen, E. M., and E. A. Willhite. 2006. Field guide to the common diseases and insect pests of Oregon and Washington Conifers. R6-NR-FID-PR-01-06. U.S. Department of Agriculture, Forest Service, Pacific Northwest Region, Portland, OR. 325p.

Grayson, L. M., R. A. Progar, and S. M. Hood. 2017. Predicting post-fire tree mortality for 14 conifers in the Pacific Northwest, USA: Model evaluation, development, and thresholds. Forest Ecology and Management **399**:213-226.

Hagle, S. K., K. Gibson, and S. Tunnock. 2003. Field guide to diseases and insect pests of Northern and Central Rocky Mountain conifers. Report Number R1-03-08. U.S. Department of Agriculture, Forest Service, State and Private Forestry, Northern Region and Intermountain Region, Missoula, MT.

Harvey, R. D., and P. F. Hessburg. 1992. Long-Range Planning for Developed Sites in the Pacific Northwest: The context of Hazard Tree Management. FPM-TP039-92. https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fsbdev2_026108.pdf.

Hood, S., and D. Lutes. 2017. Predicting post-fire tree mortality for 12 western US conifers using the First-Order Fire Effects Model (FOFEM). Fire Ecology **13**:66-84.

Hood, S., I. Ragenovich, and B. Schaupp. 2020. Post-fire Assessment of Tree Status and Marking Guidelines for Conifers in Oregon and Washington. Report Number R6-FHP-RO-2020-02. https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fseprd814664.pdf

Hood, S., M. Varner, P. van Mantgem, and C. A. Cansler. 2018. Fire and Tree Death: Understanding and Improving Modeling of Fire-induced Tree Mortality Environmental Research Letters **13**:113004.

Hood, S. M. 2010. Mitigating old tree mortality in long-unburned, fire-dependent forests: a synthesis. RMRS-GTR-238. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fort Collins, CO.

Hood, S. M., and B. Bentz. 2007. Predicting post-fire Douglas-fir beetle attacks and tree mortality in the Northern Rocky Mountains. Canadian Journal of Forest Research **37**:1058-1069.

Hood, S. M., B. Bentz, K. Gibson, K. C. Ryan, and G. DeNitto. 2007a. Assessing post-fire Douglas-fir mortality and Douglas-fir beetle attacks in the northern Rocky Mountains. RMRS-GTR-199. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fort Collins, CO.

Hood, S. M., D. R. Cluck, S. L. Smith, and K. C. Ryan. 2008. Using bark char codes to predict post-fire cambium mortality. Fire Ecology **4**:57-73.

Hood, S. M., C. McHugh, K. C. Ryan, E. Reinhardt, and S. L. Smith. 2007b. Evaluation of a post-fire tree mortality model for western US conifers. International Journal of Wildland Fire **16**:679-689.

Hood, S. M., S. Smith, and D. Cluck. 2010. Predicting tree mortality for five California conifers following wildfire. Forest Ecology and Management **260**:750-762.

Ryan, K. C. 1982. Techniques for assessing fire damage to trees. Pages 1-11 *in* J. Lotan, editor. Proceedings of the symposium: Fire, its field effects, 19-21 October 1982, Jackson, Wyoming. Intermountain Fire Council, Missoula, MT.

Ryan, K. C., and E. D. Reinhardt. 1988. Predicting postfire mortality of seven western conifers. Canadian Journal of Forest Research **18**:1291-1297.

Sieg, C. H., J. D. McMillin, J. F. Fowler, K. K. Allen, J. F. Negrón, L. L. Wadleigh, J. A. Anhold, and K. E. Gibson. 2006. Best predictors for postfire mortality of ponderosa pine trees in the Intermountain West. Forest Science **52**:718-728.

Smith, S. L., and D. R. Cluck. 2011. Marking Guidelines for Fire-Injured Trees in California. Report RO-11-01. RO-11-01, USDA Forest Service, Forest Health Protection, Region 5, Susanville, CA.

Thies, W. G., and D. J. Westlind. 2012. Validating the Malheur model for predicting ponderosa pine post-fire mortality using 24 fires in the Pacific Northwest, USA. International Journal of Wildland Fire **21**:572-582.

Thies, W. G., D. J. Westlind, M. Loewen, and G. Brenner. 2006. Prediction of delayed mortality of fire-damaged ponderosa pine following prescribed fires in eastern Oregon, USA. International Journal of Wildland Fire **15**:19-29.

Toupin, R., and M. Barger. 2005. Field Guide for Danger Tree Identification and Response. R6-NR-FP-PR-03-05.

Toupin, R., G. Filip, T. Erkert, and M. Barger. 2008. Field Guide for Danger Tree Identification and Response. R6-NR-FP-PR-01-08.

USDA Forest Service Region One. 2017. Post-fire assessment of Tree Status. Vegetation Classification, Mapping, Inventory and Analysis Report. Report 17-17 v2.0.

Woolley, T., D. C. Shaw, L. M. Ganio, and S. A. Fitzgerald. 2012. A review of logistic regression models used to predict post-fire tree mortality of western North American conifers. International Journal of Wildland Fire **21**:1-35.

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

High value natural resources found in and around the Beachie Creek Fire include populations of winter steelhead and spring Chinook (Federally Threatened), mountain whitefish, cutthroat trout and lamprey (state sensitive); Roosevelt elk and black-tailed deer, and multiple wildlife strategy species including Oregon slender salamander (state sensitive), Cascade torrent salamander (state sensitive), northern spotted owl (federal threatened), great gray owl (state sensitive), Townsend's big-eared bat (state sensitive-critical), red tree vole (state sensitive), harlequin duck (state sensitive), and golden eagle (data gap species); and key strategy habitats including late successional forest, riparian, oak woodland, and wetland habitats that support these species. Prior to the fire, much of the riparian and stream habitats supporting these values were depauperate of large woody debris (LWD) and/or vegetation suitable for supporting beavers. The Beachie Creek Fire burned these habitats with a moderate percentage of moderate to high burn severity.

8.4. Critical Values, Results, Risk Assessment, and Recommendations

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. In subsequent sections, these values are specifically evaluated for each fire.

Five Critical Values (CVs) were determined to be at risk of post-fire threats (1 at high risk), and restoration/natural recovery opportunities were identified for 9 additional CVs (8 with high reward; Table 2). ODFW will directly implement actions at Salmon Fall fish ladder to address direct threat to fish passage; in all other cases, ODFW will work with partners to address both risks and opportunities. The Little North Santiam River Area COA lies almost entirely within the fire perimeter.

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. Beachie Creek ETART Members

Beachie Creek ETART

Team Member	Resource	Agency
Jenny Meisel	Botany (Weeds)	Marion Soil and Water Conservation District
Rebecca McCoun	Botany (Weeds)	North Santiam Watershed Council
Thomas Whittington	Engineering	Oregon Department of Forestry
Charles Williams	Engineering	Marion County Public Works
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
Ryan Andrews	Hydrology	Oregon Water Resources Department
W. Terry Frueh	Hydrology	Oregon Department of Forestry
Anthony Collora	Soils	USDA Natural Resource Conservation Service

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

Clackamas County

The roads observed on non-federal forest lands pose moderate threat due to their location within the fire and damage observed. These roads will require moderate action to maintain them open and safe to all traffic. There are numerous hazard trees that are immediately adjacent to the road that pose an immediate threat to life and safety. Infrastructure was found along Copper Creek ML in the quantity of 4 culverts. Three of the four crossings are along perineal stream sections and pose a risk to damage or loss to the structure. Sedimentation is already occurring above and within each structure. Most of this sedimentation occurred before the fire but will only worsen due to the changed condition of the fire. With the anticipated increase in flows it is recommended to pull/remove the culverts and provide a temporary harden crossing until the watershed rehabs and the forest reopens this section of the road. At this time a new culvert can be sized and replaced if needed and when needed. This will allow the drainage to establish a post fire flow path, reduce sedimentation and protect the watershed below.

Marion County

Of the approximately 35 miles of County road with the Beachie Creek Fire area this report focuses on the 23 that were most affected by moderate to high burn severity. Along all roads the ditches will need to be cleaned and hazards trees removed along 19 miles of roadside. There are another 153 acres of fire killed trees in county parkland that need to be removed. The SBS map highlighted four locations where there is a high chance of debris flows intersecting the road. Field observations show that these intersections have culverts that are probably undersized for post fire storm flows. These crossings will need to be analyzed and culverts replaced. Consulting engineers have noted an additional culvert crossing that will need to be upsized to pass post burn flows. In addition to culvert work there are three locations where road repairs are required due to wind thrown trees or burnt stumps causing slope instability and two cliffs where heat loosened rocks are falling into the roadway.

Santiam State Forest

The fire has caused significant damage to the infrastructure. This information is based on the initial assessment of the road system on the Santiam State Forest. There are approximately 190 miles of road within the perimeter of the Beachie Creek Fire on the forest. There are approximately 50-70 polyethylene culverts that have been damaged by the fire and need to be replaced. There are 60-80 locations that will require some level of road repair; cut-slope ravel and ditch cleaning, burnt-out side cast material and road shoulder repair, including a general sweeping/clearing of woody debris that has blown down and adjacent to ditches.

ROAD/PARK	DESCRIPTION & ISSUES
Elk Prairie/Sawtell	▪ Well-developed and maintained paved county road ▪ Provides access to numerous rural residential dwellings and private forestland ▪ **Needs:** storm monitoring and ditch cleaning of all culverts ▪ Critical values at risk – (property)
Family Camp	▪ Surfaced (gravel) county road with heavy truck traffic ▪ Provides access to a minor amount of rural residential dwellings and primary access to state and private forestland. ▪ Connects to State Forests road system: ▪ **Needs:** hazard tree removal, storm monitoring, and ditch cleaning of all culverts ▪ Critical values at risk – (property & life safety)
Copper Creek ML	▪ Surfaced (gravel) private road with heavy truck traffic ▪ Provides gated access to large tract of private forestland, power line infrastructure, and emergency access to adjoining county and State Highway. ▪ Connects to county road and BLM roads, as well as access to Santiam river drainage. ▪ **Needs:** hazard tree removal, storm monitoring, and ditch cleaning of all culverts ▪ Critical values at risk – (property & life safety)
North Fork Rd SE Santiam State Forest Roads	▪ Well-developed and maintained paved road (major and minor collector functional class) connected to state highway 22. ▪ Surfaced (gravel) state forest roads that are generally open to public access with heavy truck traffic in the form log hauling ▪ Provides access to hundreds of year-round residences, other private timberland, heavily used and USFS/BLM road systems ▪ High public use recreation corridor for County Parks, BLM, USFS and State forests area with multiple developed areas including trail heads and day use areas. ▪ **Needs:** hydraulic analysis for several culvert crossings and most likely upsizing of culverts, hazard tree removal, storm monitoring and, storm proofing including ditch cleaning, loose rock removal on cliffs, full depth road repair ▪ Critical values at risk – property, life and safety, natural resources armoring, relief dips, and culvert replacement

ROAD/PARK	DESCRIPTION & ISSUES
Gates-Hill Rd SE	▪ Connects Hwy 22 to North Fork Rd (paved, local functional class) ▪ Provides access for a few rural residences, private timberland and power line access ▪ **Needs:** culvert inlet cleaning, storm monitoring repair, road fore slope slump caused by burned out stump and routes, hazard tree removal ▪ Critical values at risk – property, life and safety
Central Rd SE	▪ Local functional class paved road that parallels Hwy 22 in the town of Gates. ▪ Provides a bypass when crashes close Hwy 22 ▪ **Needs:** Replacement culvert has been identified as undersized by consulting engineer's analysis. Replace emergency installed culvert with larger one per engineering analysis. ▪ Critical values at risk – life/safety and property
Wagner Rd SE	▪ Local gravel road serving few residences and Christmas tree farms, access to state forestland and USFS ▪ **Needs:** Hazard tree removal, ditch cleaning and storm monitoring ▪ Critical values at risk – life/safety and property
North Fork	▪ **Needs:** Remove unstable boulder (11'x6'x7') on steep slope above popular river beach by blasting (supporting tree has burnt away), hazard tree removal ▪ Critical values at risk – life/safety and property
Bear Creek	▪ **Needs:** hazard tree removal ▪ Critical values at risk – life/safety and property
Salmon Falls	▪ **Needs:** hazard tree removal ▪ Critical values at risk – life/safety and property
Minto	▪ **Needs:** hazard tree removal ▪ Critical values at risk – life/safety and property
Packsaddle	▪ **Needs:** hazard tree removal ▪ Critical values at risk – life/safety and property
Niagara	▪ **Needs:** hazard tree removal ▪ Critical values at risk – life/safety and property

Table 2. Clackamas County Road Treatments Cost Estimate

Mobilization	Quantity	Rate	Method	Unit	Total
Mobilization (total – all treatments)	1	$2,500	LSQ	Lump Sum	$2,500
Mobilization Total					**$2,500**

Hazard Tree Removal	Quantity	Rate	Method	Unit	Total
Removal crew on county roads	2	$8,500	AQ	Day	$17,000
Hazard Tree Removal Total					**$17,000**

Storm Inspection and Response	Quantity	Rate	Method	Unit	Total
Monitoring crew	2	$900	NA	Day	$1,800
Vehicles, Equipment and Misc.	2	$300	NA	Day	$900
Storm Inspection and Response Total					**$2,700**
Clackamas County Road Treatment Total					**$22,200**

Table 3. Marion County Road Treatments Cost Estimate

Storm Proofing	Quantity	Rate	Unit	Total
Clean Ditches and Inlets	25	$750	Mile	$18,750
Storm Proofing Treatment Total				**$18,750**

Culvert Replacement	Quantity	Rate	Unit	Total
Culvert Crossing Replacement (Five crossings from 24"-108", materials, equipment, labor, mobilization pending engineering analysis of post burn storm flow and current culvert capacity)	1	$241,000	Lump Sum	$241,000
Treatment Total				**$241,000**

Hazard Tree Clearing (153 acres in parks, 23 roadside miles)	Quantity	Rate	Unit	Total
Felling crew (contract)	40	$2,000	Day	$80,000
Machine Felling	40	$1,000	Day	$40,000
Vehicles and Equipment	1	$5,000	Lump Sum	$5,000
Treatment Total				**$125,000**

Hazard Rock Removal	Quantity	Rate	Unit	Total
Scalers, two rappelling, one ground person	20,000	$1.13	SF	$22,600
Treatment Total				**$22,600**

Road Repair	Quantity	Rate	Unit	Total
Mobilization	1	$5,000	Lump Sum	$5,000
Asphalt Concrete Pavement Repair	60	$250	SY	$15,000
Asphalt Concrete Pavement in Base Plug	17	$300	TN	$5,100
Treatment Total				**$25,100**

Storm Inspection and Response	Quantity	Rate	Unit	Total
Marion County Staff Employees (2 per response)	10	$800	Day	$8,000
Vehicles and Equipment	5	$500	Each	$2,500
Treatment Total				**$10,500**
Marion County Treatment Total				**$442,950**

Table 4. Santiam State Forest Road Treatments Cost Estimate

Mobilization	Quantity	Rate	Method	Unit	Total
Mobilization (total - all treatments) multiple locations	5	$1,500	LSQ	Lump Sum	$7,500

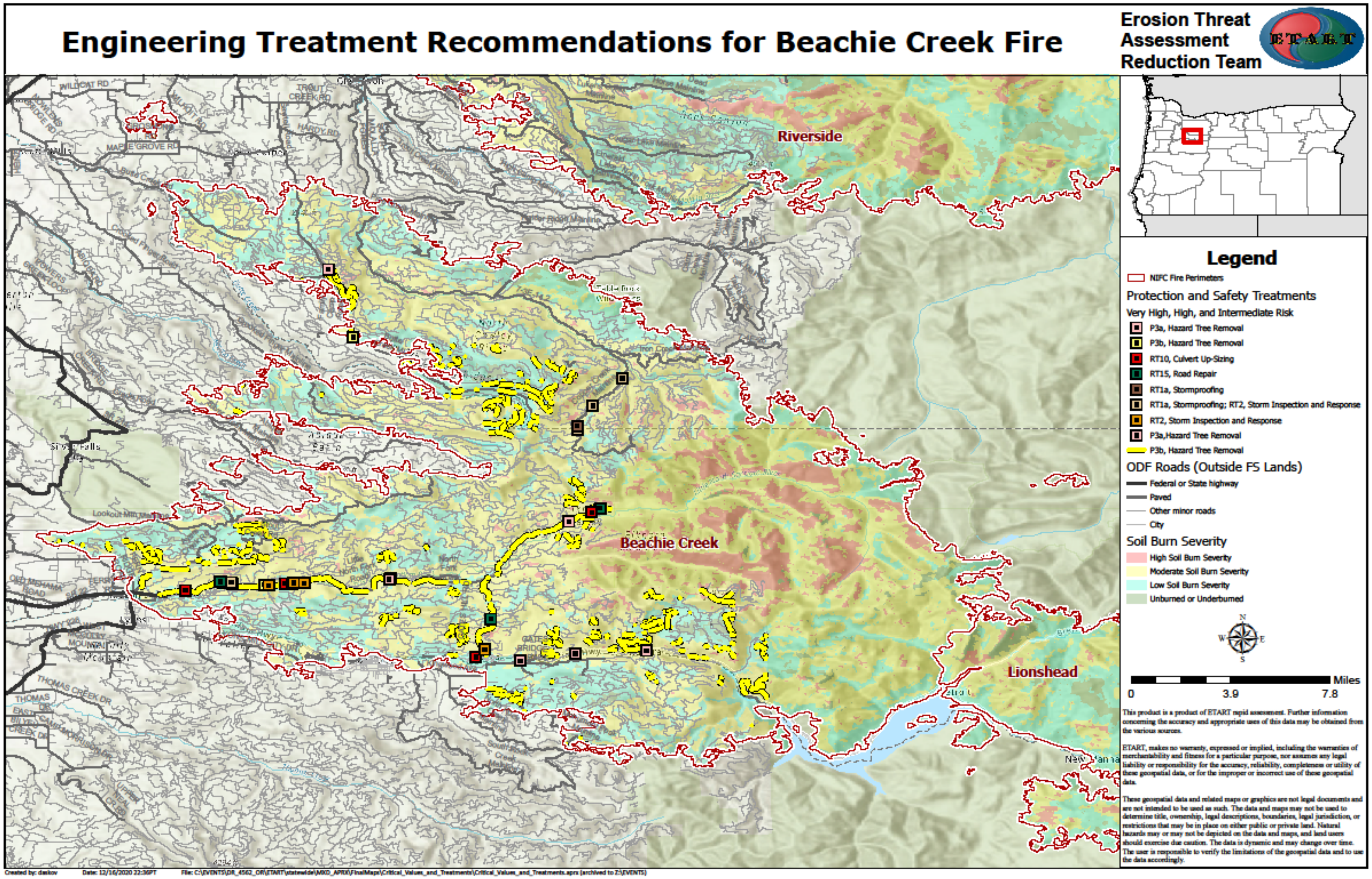
Mobilization Total	**$1,500**

Storm Proofing	Quantity	Rate	Method	UOM	Total
Outslope Road Prism, Conserve Roadside Rock for Crossings	10	$1,200	DQ	Mile	$12,000
Construct Rolling Dip	5	$500	AQ	Each	$2,500
Armored Critical Dip	2	$3,900	DQ	Each	$7,800
Clean Ditches	60	$750	DQ	Mile	$45,000
Storm Proofing Treatment Total					**$67,300**

Culvert Replacement	Quantity	Rate	Method	UOM	Total
Plastic Culvert Replacement (materials, equipment, labor)	50	$1,250	DQ	Each	$62,500
Metal Culvert Replacement	5	$2,500	DQ	Each	$12,500
Treatment Total					**$75,000**

Hazard Tree Clearing	Quantity	Rate	Method	UOM	Total
Felling crew (contract)	5	$2,000	AQ	Day	$0,000
Roadside Machine felling	5	$1,000	AQ	Day	$5,000
Vehicles and Equipment	1	$2,000	AQ	Lump Sum	$1,000
Treatment Total					**$16,000**

Storm Inspection and Response	Quantity	Rate	Method	UOM	Total
ODF Staff Employees (2 per response)	10	$800	AQ	Day	$8,000
Vehicles and Equipment	5	$500	AQ	Each	$2,500
Treatment Total					**$10,500**
State Forests Treatment Total					**$176,300**


Engineering Treatment Recommendations for Beachie Creek Fire
Erosion Threat Assessment Reduction Team
Riverside
Beachie Creek
Lionshead
Legend
NIFC Fire Perimeters
Protection and Safety Treatments
Very High, High, and Intermediate Risk
P3a, Hazard Tree Removal
P3b, Hazard Tree Removal
RT10, Culvert Up-Sizing
RT15, Road Repair
RT1a, Stormproofing
RT1a, Stormproofing; RT2, Storm Inspection and Response
RT2, Storm Inspection and Response
P3a,Hazard Tree Removal
P3b, Hazard Tree Removal
ODF Roads (Outside FS Lands)
Federal or State highway
Paved
Other minor roads
City
Soil Burn Severity
High Soil Burn Severity
Moderate Soil Burn Severity
Low Soil Burn Severity
Unburned or Underburned
N
W
E
S
Miles
0
3.9
7.8
This product is a product of ETART rapid assessment. Further information concerning the accuracy and appropriate uses of this data may be obtained from the various sources.
ETART, makes no warranty, expressed or implied, including the warranties of merchantability and fitness for a particular purpose, nor assumes any legal liability or responsibility for the accuracy, reliability, completeness or utility of these geospatial data, or for the improper or incorrect use of these geospatial data.
These geospatial data and related maps or graphics are not legal documents and are not intended to be used as such. The data and maps may not be used to determine title, ownership, legal descriptions, boundaries, legal jurisdiction, or restrictions that may be in place on either public or private land. Natural hazards may or may not be depicted on the data and maps, and land users should exercise due caution. The data is dynamic and may change over time. The user is responsible to verify the limitations of the geospatial data and to use the data accordingly.

Appendix B – Invasive Plant Species Information, Treatment Design, and Cost Estimates

I. Oregon Department of Agriculture Noxious Weed Rankings

A-Listed Weeds: A weed of known economic importance which occurs in the state is small enough infestations to make eradication or containment possible. Or, it is not known to occur, but its presence in neighboring states make future occurrences in Oregon seem imminent.

B-Listed Weeds: A weed of economic importance, which is regionally abundant, but which may have limited distribution in some counties. Intensive control is limited at the state, county or regional level as determined on a site specific, case-by-case basis. Where implementation of a fully integrated state management plan is not feasible, biological controls shall be the primary control method.

T-Designated Weeds: A group of species that will be the focus of prevention and control by the Noxious Weed Control Program. Actions against these weeds will receive priority in implementing a statewide management plan. These species can be selected from either the A or the B Lists. (Oregon Department of Agriculture, Noxious Weed Classification System 2019).

II. Invasive Plant Profiles of Selected Species

Slender false brome (Brachypodium sylvaticum) is an aggressive, shade tolerant, perennial understory bunch grass that forms clumped “lawns” on forest floors which have never historically had continuous grass cover. Consecutive year’s growth forms thick thatched layers which create flash fuels that are a driver for higher severity fire regimes (Pausas & Keeley 2009). Studies have shown that consistent high intensity fire can reduce and even eradicate populations, but that non-uniform fire intensity, specifically low severity fire, contributes greatly to its spread by reducing competitive vegetation. Once it is established, it propagates a self-perpetuating “grass-fire cycle” that alters an ecosystem in a way that increases the likelihood of its own success (Poulos & Roy 2015). It is not rhizomatous, propagating only by seed.

Diffuse knapweed (Centaurea diffusa) is an annual, biennial, or short-lived perennial. Once it has become established, it can form monotypic stands. Diffuse knapweed’s competitive ability has been attributed to depleting soil moisture, release of allelopathic compounds, and to other interference mechanisms. Diffuse knapweed produces an average of 1200 fire-tolerant seeds per plant that are dispersed by wind, animal, shoes and vehicles. Fire provides an ideal seedbed by removing shade, competitive plants and exposing mineral soil. Disturbance also allows knapweed to invade a wide range of habitats, where it can rapidly establish dense, often monotypic, stands. Diffuse knapweed has a large, perennial taproot that may survive fire if the root crown is not killed.

Meadow knapweed (Centaurea x moncktonii) is an annual, biennial, or short-lived perennial. Once it is established, this knapweed can form monotypic stands. The competitive ability of meadow knapweed has been attributed to its being adept at depleting soil moisture, to allelopathy, and to other competitive or interference mechanisms. Produces an average of 1200 fire-tolerant seeds per plant that are wind, animal, vehicle and shoe dispersed. Fire provides an ideal seedbed by removing shade and exposing mineral soil. This plant has a wide range of germination behavior with respect to light and moisture. Disturbance also allows knapweed to invade a wide range of habitats, where it can rapidly establish dense, often monotypic, stands. Meadow knapweed also has a large, perennial taproot that may survive fire if the root crown is not killed.

Spotted knapweed (Centaurea stoebe) is a nonnative, perennial forb that can live at least 9 years. Once established, spotted knapweed can form monotypic stands because its age class hierarchy allows it to occupy all available niches. Spotted knapweed produces large quantities of durable, heat-tolerant seed that are known for their longevity and durability. They can survive most grassland fires, although a high severity fire may kill some spotted knapweed seeds. Spotted knapweed also has a large, perennial taproot that is likely to survive and re-sprout after fire if the root crown is not killed.

Himalayan Blackberry (Rubus armeniacus). Blackberries are typically observed in greatest abundance following fire or other types of disturbance, sprouting vigorously after fire. Rhizomes located at or below the ground surface re-sprout even when aboveground foliage is totally consumed by fire. Plants can readily reoccupy recently burned sites through well stocked seedbanks protected from the direct effects of fire by overlying soil or duff. Seed generally remains viable for long periods of time and germinates in abundance after disturbance. Exposed mineral soils provide a favorable seedbed for seed establishment, and extensive establishment of blackberry is commonly observed after fires. Birds and mammals may also transport some viable seed to the site. The Himalayan blackberry is described as a "serious pest" which is well represented on many types of disturbed sites. Its role as a vigorous invader on waste ground suggests the potential for rapid postfire recovery in many areas.

Tansy ragwort (Senecio jacobeae). Tansy ragwort is a winter annual, biennial, or short-lived perennial. However, because both the root and the caudex of this species have the capacity to form perennating buds under environmental or mechanical stress, tansy ragwort has the vegetative regenerative capacity of a perennial. Alkaloids produced by rosettes may have the allelopathic effect of suppressing other plants. Tansy ragwort can reduce forage yields by as much as 50% in pastures. Pyrrolizidine alkaloids are present in all plant parts. Cattle, deer, horses and goats consuming either growing plants or tansy ragwort in silage and hay and then store these alkaloids in their livers. The pappus on the achene of tansy ragwort facilitates wind dispersal. However, achenes are generally considered to be poor wind dispersers and studies suggest 60% of tansy ragwort seeds fall within seven feet (2 meters) of the parent plant with only 0.5% of seeds produced becoming wind borne. Seeds can also disperse by water movement, through the digestive tract and adhering to the fur of livestock and other animals, and viable seeds have been collected from bird droppings. In Montana, tansy ragwort has established on logging sites and clearings, implicating equipment used for logging as a long-distance spread vector. In an open plant community, fire is effective in killing reproductive tansy ragwort plants and achenes. It can also be used to maintain the vigor and density of grassland communities by burning excess plant litter and possibly increasing soil fertility. In meadow ecosystems, fire can therefore be used as a preventative measure or in combination with other control methods to reduce tansy ragwort populations. On forested sites and clearings, however, the disturbance caused by fire may create openings favorable to tansy ragwort invasion. Herbicide and very intensive hand pulling can be effective methods of control.

French broom (Genista monspessulana), Portuguese broom (Cytisus striatus) and Scotch broom (Cytisus scoparius). These plants both sprout from the root crown and aboveground stem after top-kill from fire (Boyd 1995, Downy 2000). Bossard (2002) suggests that French broom burns readily and carries fire to the tree canopy layer, increasing both the frequency and intensity of fires in invaded areas. Fire is likely to top-kills these species, although some reports indicate that these species may be difficult to burn in some situations. Conversely, high-severity fires or fires in some seasons may kill the entire plant and prevent postfire sprouting (Boyd 1995). Germination of both of these brooms from the soil seed bank appears to be induced by fire, as high seedling densities occur after a single fire. Laboratory tests support the notion that heat from fire scarifies their seed and stimulates germination. Based on observations and experiments by several authors, a high potential for postfire colonization of broom's exists wherever there are existing stands or viable seeds in the soil seed bank.

Knotweeds: Japanese, Giant and Bohemian (Polygonum and Fallopia spp). Fire likely only top-kills the 3 knotweeds and does little damage to below ground parts. Seedlings may be killed by fire if they have not developed substantial underground reserves. As of 2010, no information was available on fire effects on or heat tolerance of seeds of the 3 knotweeds.

The ability of the 3 knotweeds to sprout, particularly from rhizomes, roots, and root crowns, suggests that top-killed plants are likely to regenerate following fire. The deep root penetration and lateral spread of rhizomes of giant, Japanese and Bohemian knotweed likely improve their chances of surviving and sprouting following fire. Japanese knotweed rhizomes may sprout from as deep as 3 feet (1 m). Some evidence suggests that Japanese knotweed rhizome sprouting may increase under high-light conditions which are likely following fire. Fire season may not impact the ability of the 3 knotweeds to regenerate vegetatively; in New Jersey field experiments, planted Japanese knotweed rhizomes were able to sprout throughout the growing season. However, fires occurring just prior to senescence in the fall could impact resource allocation to underground reserves. Giant and Japanese knotweed exhibit rapid growth which would facilitate recovery following top kill. There is also some evidence to suggest that high-light conditions favor Japanese and giant knotweed growth. Preventing postfire establishment and spread: Because both seeds and plant parts are often dispersed by water, it is possible that the 3 knotweeds may colonize burned areas adjacent to watercourses. Monitoring of burned riparian areas downstream from known populations of the 3 knotweeds is advised. (FEIS).

Garlic Mustard (Allaira petiolata). Garlic mustard is often top-killed when exposed to fire and plants are readily killed by mid-intensity dormant season fires. Emergent seedlings may also be killed by fire. At the population level, garlic mustard may be adapted to perpetuate itself in mixed-severity or low-severity surface fire regimes, although this has not been quantified. Even though individual plants may be killed by fire, postfire conditions may be favorable for rapid population expansion because of increases in the area of disturbed habitat and, depending on the extant community, temporary reductions in interspecific competition. Additionally, garlic mustard seed banks may facilitate rapid recolonization of disturbed areas. The ability of individual plants to escape mortality will depend upon fire severity and the heterogeneity of the fire landscape. (FEIS).

III. Marion County Weed List

Table 6. Marion County Weed Control District Weed List

Educate and Control	Immediate Action/Eradication
False brome *Brachypodium sylvaticum*	Common gorse *Ulex europaeus*
Giant, Japanese and Himalayan or Bohemian knotweeds *Polygonum sp. or Fallopia sp*	Diffuse knapweed *Centaurea diffusa*
Meadow knapweed *Centaurea x moncktonii*	Garlic mustard *Allaria petiolata*
Spotted knapweed *Centaurea pratensis*	Giant Hogweed *Heracleum mantegazzianum*
Milk thistle *Silybum marianum*	Italian thistle *Carduus pycnocephalus*
Puncturevine *Tribulus terrestris*	Kochia *Kochia scoparia*
Purple loosestrife *Lythrum salicaria*	Oblong Spurge *Euphorbia oblongata*
Tansy Ragwort *Senecio jacobea*	Paterson's curse *Echium plantagineum*
Yellow flag iris *Iris pseudacorus*	Rush skeletonweed *Chondrilla juncea*
Yellow toadflax *Linaria vulgaris*	Yellow starthistle *Centaurea solstitialis*
	Traveler's Joy *Clematis vitalba*

IV. Clackamas County Weed list

Please visit the Weedwise website at the following link: https://weedwise.conservationdistrict.org/weeds

V. Treatment Cost Estimates

Table 7. Estimated Treatment Cost

Rehabilitation Item	Number	Unit	Estimated Cost/Unit	Description of costs
ETART non-suppression EDRR (natural vegetation protection areas)	433	Acres	$360/acre Spring Comb Spray $280/acre Fall Spot Spray $62/hr = Surveying and Monitoring	Spring 2021 and Fall 2021 Early detection rapid response surveys and treatment in natural vegetation protection areas that experienced Mod/High severity burning and is adjacent to known weed populations.
ETART non-suppression EDRR (roads and trails)	49.8/18	Miles/acres	$360/acre Spring Comb Spray $280/acre Fall Spot Spray $62/hr = Surveying and Monitoring	Spring 2021 and Fall 2021 Early detection rapid response surveys and treatment along roadsides and trails that experienced Mod/High severity burning and are adjacent to known weed populations.

Rehabilitation Item	Number	Unit	Estimated Cost/Unit	Description of costs
Suppression EDRR (suppression lines)	177.2/ 291	Miles/ Acres	$360/acre Spring Comb Spray $280/acre Fall Spot Spray $62/hr = Surveying and Monitoring	Spring 2021 and Fall 2021 Early detection rapid response surveys and treatment on the dozer line, hand line and road completed line.
Suppression EDRR (drop points)	63	Each	$360/acre Spring Comb Spray $280/acre Fall Spot Spray $62/hr = Surveying and Monitoring	Spring 2021 and Fall 2021 Early detection rapid response surveys and treatment of drop points/staging areas. Acres unknown
Weed Wash Stations for Equipment	2	each	$2,000/Station/day	Place in areas with heavy traffic entering and exiting the fire area; Lyons and Scotts Mills
Re-establish Biological controls in fire area	1	month	$10,412.83	ODA employee cost for collection, release and monitoring of biological control agents

Rehabilitation Item	Number	Unit	Estimated Cost/Unit	Description of costs
Native Seed for suppression lines and drop points	177	Acre	$140/acre	Blue Wildrye native seed (Broadcast seeding at 14lbs/acre)
Boot brushes	14	each	$600	Hardware and installation cost
Bare root plants		Each	$1.00	As needed for future plantings
Native Seed		pound	$10.00	As needed for future plantings

** Costs are based on 2 seasons; spring and fall treatments

ETART EDRR

- EDRR treatments and surveys on 433 acres of natural vegetation protection areas.
- Recreational Areas & Open Roadways:
  - Oregon Department of Forestry: 20.8 miles of trails; 7 boot brush stations;
  - Oregon Parks and Recreation Department: 4 miles of trails; 2 boot brush stations;
  - Marion County Parks: 5 miles of trails; 5 boot brush stations;
  - 20 miles of North Fork Road from Hwy 22 to federal lands.

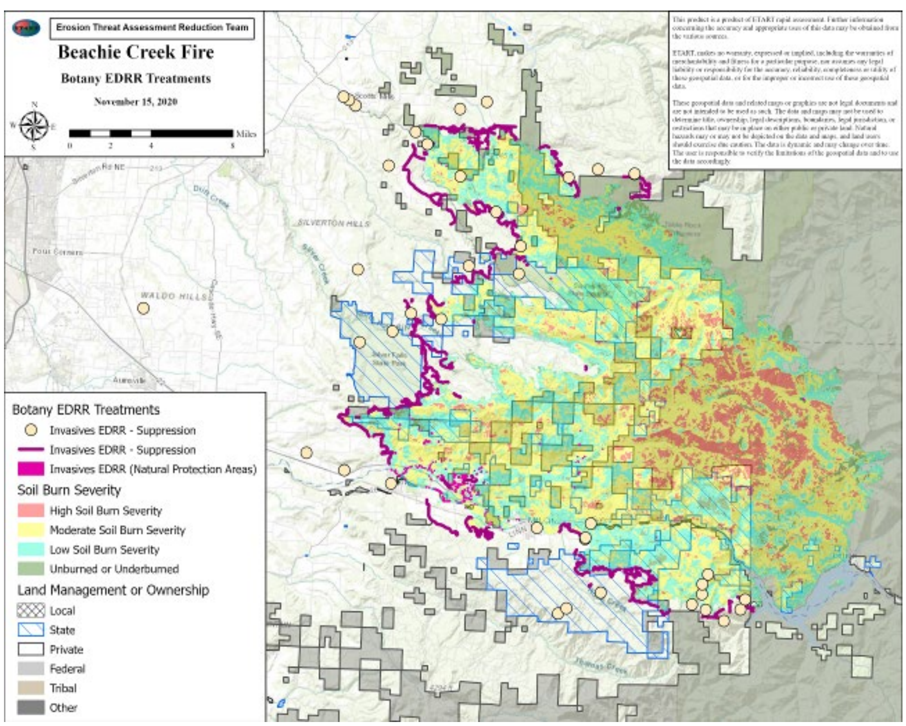


Figure 1. ETART Fire Suppression Treatments - Beachie Creek Fire

ETART Fire Suppression EDRR

Approximately 177 miles of dozer line, hand line and road as completed line were constructed on non-federal lands. Roughly 63 suppression points were used during firefighting activities (Figure 6, Table 8). The total acres for suppression points is unknown, but these sites should be surveyed and treated for any potential infestations. For suppression activities on state, county and local lands, landowners/managers should consider excluding traffic and recreation use in these areas until native vegetation is well established (at least 2 growing seasons).

ETART EDRR		
Disturbed Area	**Units**	**Notes**
Natural vegetation protection areas: EDRR surveys and treatments	433 acres	Within high & moderate soil burn severity only.
Trails and Roads: EDRR surveys and treatments	50 miles	Within high & moderate soil burn severity only. Trails: 29.8 miles; Roads: 20 miles.
Trails and Roads: boot brush stations	14 each	One at each park or recreation area.
Trails and Roads: equipment wash station	2 each	Intersection of North Fork Road and Hwy 22 in Lyons; near Scotts Mills.
ETART Suppression EDRR		
Disturbance	**Units**	**Notes**
Dozer lines/hand lines: EDRR surveys, treatments and seeding	177 miles (291 acres)	Non-federal lands inside and outside of the fire perimeter. Apply native blue wildrye seed at 14 lbs/acre.
Suppression points: EDRR surveys, treatments and seeding	63	Non-federal lands inside and outside of the fire perimeter (acres not known). Seeding native blue wildrye @ 14lbs/acre.

Treatment or Response Action	Unit	Number	Estimated Unit Cost	Description of Cost
ETART EDRR (natural vegetation protection areas)	Acres	433	▪ $360/acre Spring Comb Spray ▪ $280/acre Fall Spot Spray ▪ $62/hr = Survey and Monitor	Spring 2021 and Fall 2021 Early detection rapid response surveys and treatment in natural vegetation protection areas that experienced Mod/High severity burning and is adjacent to known weed populations.
ETART EDRR (roads and trails)	Miles (Acres)	50 (18)	▪ $360/acre Spring Comb Spray ▪ $280/acre Fall Spot Spray ▪ $62/hr = Survey and Monitor	Spring 2021 and Fall 2021 Early detection rapid response surveys and treatment along roadsides and trails that experienced Mod/High severity burning and are adjacent to known weed populations.
ETART Suppression EDRR (suppression lines)	Miles (Acres)	177 (291)	▪ $360/acre Spring Comb Spray ▪ $280/acre Fall Spot Spray ▪ $62/hr = Survey and Monitor	Spring 2021 and Fall 2021 Early detection rapid response surveys and treatment on the dozer line, hand line and road completed line.
ETART Suppression EDRR (drop points)	Each	63	▪ $360/acre Spring Comb Spray ▪ $280/acre Fall Spot Spray ▪ $62/hr = Survey and Monitor	Spring 2021 and Fall 2021 Early detection rapid response surveys and treatment of drop points/staging areas. Acres unknown
Weed Wash Stations for Equipment	Each	2	$2,000/Station /day	Place in areas with heavy traffic entering and exiting the fire area; Lyons and Scotts Mills

Treatment or Response Action	Unit	Number	Estimated Unit Cost	Description of Cost
Re-establish biological controls in fire area	Month	1	$10,413	ODA employee cost for collection, release and monitoring of biological control agents
Native seed for suppression lines and drop points	Acre	177	$140/acre	Blue Wildrye native seed (Broadcast seeding at 14 lbs/acre)
Boot brushes	Each	14	$600	Hardware and installation cost
Bare root plants	Each		$1.00	As needed for future plantings
Native Seed	Pound		$10.00	As needed for future plantings

Best Management Practices (BMP) Recommendations

An integrated best management approach is recommended for treating invasive plants in the Beachie Creek fire. This report recommends two EDRR treatments the first year, spring 2021 and fall 2021. Columbia Gorge and 4-County Cooperative Weed Management Areas (CWMA) have Best Management Practices for treatment of many invasive species described in this report.

Timing of treatments for invasive species is critical for long term control. Some species, such as Himalayan Blackberry require two treatments per year for control. Clean Water Services provides treatment recommendations in a weed control calendar as part of their Integrated Pest Management Plan that can be used to determine the best timing for long term control of invasive plants. The 4-County CWMA also created a weed control calendar in November of 2020. Consultation with a local Oregon Department of Agriculture Noxious Weed Specialist is also recommended for treatments of invasive species.

- Columbia Gorge CWMA Best Management Practices: https://columbiagorgecwma.org/weed-listing/best-management-practices/
- 4- County CWMA Best Management Practices: https://4countycwma.org/aweeds/best-management-practices/
- Clean Water Services Integrated Pest Management Plan (with weed control calendar in appendix): https://www.cleanwaterservices.org/media/1289/integrated-pest-management-plan.pdf
- 4-County CWMA Integrated Weed Maintenance Calendar: https://4countycwma.org/integrated-weed-maintenance-calendar/

Biological Controls

Recovery and maintenance of weed biological control "nursery sites" for insects that have been introduced to help control invasive plants is an important treatment consideration for this fire area. There are several biocontrol agents that were impacted by the Beachie Creek Fire:

- Scotch broom seed predators (2 species)
- Canada thistle agents (2 species)
- Bull thistle seed head fly
- Tansy ragwort control agents (several species)
- Knapweed biological control agents (several species)
- St. John's-wort root borer and leaf beetles

Education & Outreach

Conduct education and outreach in the communities affected by the fire to teach residents about the invasive species that pose the greatest threats and how to control them. Education on native plants to plant after fires is also important to help re-build resilient native plant communities to resist future invasive plant invasions.

Monitoring

Monitoring treatments for at least 3 to 5 years post fire in critical value habitat areas and in suppression areas is highly recommended. Initial post fire assessments should be made in the spring of 2021. Changes in site conditions should be documented annually in the spring before chemical treatments for up 3 to 5 years. One to two photo points should be set up in areas of highest concern. Photo points should be taken around the same time each year.

Plant community composition will be changing for several years post fire and disturbance from multiple sources will also continue for years. Salvage logging, hazard tree removal, fire event caused tree blow down, clean-up of burned structures, restoration of power to the area, and new construction are all threats that could spread or introduce new invasive plants into the burned area.

Some species, such as knotweeds, may take several years to eradicate from an area. Eradication may not be achieved in only 1 year of treatment if invasive plant species were already present in an area, so it is important to continue treatments and monitoring beyond 1 year.

If there is a heavy infestation that is eradicated within the 3-5 year timeframe, consider seeding with native seed if the natural vegetation is not showing signs of recovery.

Future Threats and Considerations

- Seed mixes or straw/hay applied by homeowners is a threat to the landscape because it may have contained weed seeds. Free non-native seed was provided by a local business to landowners impacted by the fires. Landowners on Jennie Rd. and Santiam Park Rd. are known to have used this seed mix. All sites are not known as many landowners applied seed from various sources to their properties soon after the fire to help prevent erosion.

- It was not possible to thoroughly assess all burned areas in a short amount of time. There may be localized sites in high and moderate burn severity areas where additional planting and/or seeding are needed that are found with additional surveys and as more areas of the fire are accessed but are not specifically addressed in this report. These areas should be considered for funding as necessary.

A complete assessment of invasive plants in the entire fire area was not possible for this report and analyses were completed with the invasive plant data that was currently available. There may be additional noxious weeds and invasive plants within the fire area that are not captured in this analysis and report. Adaptations will need to be made throughout the next several years to address additional species that may be found within the fire perimeter.

Appendix C – Supporting Soil Information

I. Soil Types and Erosion Hazard

II. Field Indicators of Soil Burn Severity

I. Soil Types and Erosion Hazard

Map Unit	Name	Taxonomic Classification	Soil Erosion Hazard	Total Map Unit Acres
101 D	Wilhoit-Zygore gravelly loams, 5 to 30 percent slopes	Fine-loamy, mixed, frigid Andic Haplumbrepts	Slight	36.5
103 E	Zygore-Wilhoit gravelly loams, 30 to 60 percent slopes	Loamy-skeletal, mixed, frigid Andic Haplumbrepts	Severe	125.3
10E	Bensley stony loam, 2 to 30 percent slopes	Loamy-skeletal, mixed Dystric Cryochrepts	Slight	357.5
11F	Bensley-Valsetz stony loams, 30 to 50 percent slopes	Loamy-skeletal, mixed Dystric Cryochrepts	Moderate	719.5
11G	Bensley-Valsetz stony loams, 50 to 75 percent slopes	Loamy-skeletal, mixed Dystric Cryochrepts	Severe	791.7
17	Clackamas silt loam	Fine-loamy, mixed, mesic Typic Argiaquolls	Slight	1.5
17C	Bull Run silt loam, 3 to 15 percent slopes	Medial, mesic Umbric Vitrandepts	Moderate	624.5
17E	Bull Run silt loam, 15 to 30 percent slopes	Medial, mesic Umbric Vitrandepts	Severe	404.4
18	Camas gravelly sandy loam	Sandy-skeletal, mixed, mesic Fluventic Haploxerolls	Slight	162.5
19	Chapman loam	Fine-loamy, mixed, mesic Cumulic Ultic Haploxerolls	Slight	7.7
20	Coburg silty clay loam	Fine, mixed, mesic Pachic Ultic Argixerolls	Slight	40.5
20C	Chehalem silt loam, 3 to 12 percent slopes	Fine, mixed, mesic Cumulic Haplaquolls	Moderate	0

Map Unit	Name	Taxonomic Classification	Soil Erosion Hazard	Total Map Unit Acres
21	Chehalis silty clay loam	Fine-silty, mixed, mesic Cumulic Ultic Haploxerolls	Slight	0.5
23	Clackamas gravelly silt loam	Fine-loamy, mixed, mesic Typic Argiaquolls	Slight	5.2
24B	Cottrell silty clay loam, 2 to 8 percent slopes	Clayey, mixed, mesic Aquic Haplohumults	Slight	37.2
24C	Cottrell silty clay loam, 8 to 15 percent slopes	Clayey, mixed, mesic Aquic Haplohumults	Moderate	0.3
2C	Alspaugh clay loam, 8 to 15 percent slopes	Clayey, mixed, mesic Humic Hapludults	Moderate	158.6
2D	Alspaugh clay loam, 15 to 30 percent slopes	Clayey, mixed, mesic Humic Hapludults	Moderate	337.8
2E	Alspaugh clay loam, 30 to 50 percent slopes	Clayey, mixed, mesic Humic Hapludults	Severe	528
30D	Crabtree stony loam, 2 to 25 percent slopes	Loamy-skeletal, mixed Aquic Cryochrepts	Slight	241.8
30F	Crabtree stony loam, 25 to 45 percent slopes	Loamy-skeletal, mixed Aquic Cryochrepts	Moderate	5.6
32D	Fernwood very gravelly loam, 5 to 30 percent slopes	Loamy-skeletal, mixed, frigid Andic Haplumbrepts	Slight	10.6
32E	Fernwood very gravelly loam, 30 to 60 percent slopes	Loamy-skeletal, mixed, frigid Andic Haplumbrepts	Moderate	97.6
33F	Fernwood-Rock outcrop complex, 50 to 90 percent slopes	Loamy-skeletal, mixed, frigid Andic Haplumbrepts	Severe	858.1
34D	Fernwood-Wilhoit complex, 5 to 30 percent slopes	Loamy-skeletal, mixed, frigid Andic Haplumbrepts	Slight	1316.3
36C	Hardscrabble silt loam, 7 to 20 percent slopes	Fine, mixed, mesic Aquic Palexeralfs	Severe	1650.2
36D	Dupee silt loam, 3 to 20 percent slopes	Fine, mixed, mesic Aquultic Haploxeralfs	Severe	346.5
37D	Flane gravelly loam, 3 to 25 percent slopes	Clayey-skeletal, mixed, frigid Umbric Dystrochrepts	Slight	160.1

Map Unit	Name	Taxonomic Classification	Soil Erosion Hazard	Total Map Unit Acres
37F	Flane gravelly loam, 25 to 50 percent slopes	Clayey-skeletal, mixed, frigid Umbric Dystrochrepts	Moderate	89.1
37G	Flane gravelly loam, 50 to 75 percent slopes	Clayey-skeletal, mixed, frigid Umbric Dystrochrepts	Severe	190
38E	Highcamp very gravelly loam, 30 to 60 percent slopes	Medial-skeletal, frigid Typic Haplocryands	Severe	12.4
38F	Flane-Moe gravelly loams, 25 to 50 percent slopes	Clayey-skeletal, mixed, frigid Umbric Dystrochrepts	Moderate	938.8
38G	Flane-Moe gravelly loam, 50 to 75 percent slopes	Clayey-skeletal, mixed, frigid Umbric Dystrochrepts	Severe	22.6
39	Fluvents-Fluvaquents complex, nearly level	Mesic Fluvents	Not rated	32.7
39F	Highcamp-Rock outcrop complex, 50 to 90 percent slopes	Medial-skeletal, frigid Typic Haplocryands	Severe	156.1
40D	Highcamp-Soosap complex, 5 to 30 percent slopes	Medial-skeletal, frigid Typic Haplocryands	Moderate	1900.1
40G	Harrington-Klickitat complex, 50 to 75 percent north slopes	Loamy-skeletal, mixed, mesic Typic Haplumbrepts	Severe	319.4
42H	Harrington-Rock outcrop complex, 50 to 90 percent slopes	Loamy-skeletal, mixed, mesic Typic Haplumbrepts	Severe	187.1
43D	Humaquepts, 2 to 20 percent slopes	Mesic Humaquepts	Moderate	181
44E	Henline very stony sandy loam, 6 to 30 percent slopes	Loamy-skeletal, mixed Entic Cryumbrepts	Slight	9.6
44F	Henline very stony sandy loam, 30 to 55 percent slopes	Loamy-skeletal, mixed Entic Cryumbrepts	Moderate	13.9
44G	Henline very stony sandy loam, 55 to 80 percent slopes	Loamy-skeletal, mixed Entic Cryumbrepts	Moderate	328.6
45F	Henline-Yellowstone-Rock outcrop complex, 25 to 50 percent slopes	Loamy-skeletal, mixed Entic Cryumbrepts	Slight	455.3
45H	Henline-Yellowstone-Rock outcrop complex, 50 to 90 percent slopes	Loamy-skeletal, mixed Entic Cryumbrepts	Moderate	161.1

Map Unit	Name	Taxonomic Classification	Soil Erosion Hazard	Total Map Unit Acres
47C	Kinney cobbly loam, 3 to 20 percent slopes	Fine-loamy, mixed, mesic Andic Haplumbrepts	Moderate	1269.5
47E	Kinney cobbly loam, 20 to 50 percent slopes	Fine-loamy, mixed, mesic Andic Haplumbrepts	Severe	304
49D	Kinzel-Divers complex, 5 to 30 percent slopes	Medial-skeletal, frigid Typic Haplocryands	Slight	23.3
49E	Kinzel-Divers complex, 30 to 60 percent slopes	Medial-skeletal, frigid Typic Haplocryands	Moderate	222.5
4E	Andic Cryaquepts, moderately steep	Aquandic Cryaquepts	Slight	1054.5
4F	Andic Cryaquepts, steep	Aquandic Cryaquepts	Moderate	83.3
50D	Hummington very gravelly loam, 5 to 25 percent slopes	Medial-skeletal Dystric Cryandepts	Moderate	45.5
50F	Hummington very gravelly loam, 25 to 50 percent slopes	Medial-skeletal Dystric Cryandepts	Severe	47.5
50G	Hummington very gravelly loam, 50 to 75 percent slopes	Medial-skeletal Dystric Cryandepts	Severe	51.9
51E	Klickitat stony loam, 30 to 60 percent slopes	Loamy-skeletal, mixed, mesic Typic Haplumbrepts	Moderate	23.8
52D	Klickitat-Kinney complex, 5 to 30 percent slopes	Loamy-skeletal, mixed, mesic Typic Haplumbrepts	Slight	1837.9
52F	Keel gravelly silt loam, 25 to 45 percent slopes	Medial Dystric Cryandepts	Severe	1481.2
52G	Keel gravelly silt loam, 45 to 75 percent slopes	Medial Dystric Cryandepts	Severe	9.8
54D	Kinney cobbly loam, 3 to 20 percent slopes	Fine-loamy, mixed, mesic Andic Haplumbrepts	Slight	48.3
55F	Kinney cobbly loam, 20 to 50 percent north slopes	Fine-loamy, mixed, mesic Andic Haplumbrepts	Moderate	144.9
55G	Kinney cobbly loam, 50 to 70 percent north slopes	Fine-loamy, mixed, mesic Andic Haplumbrepts	Severe	260.5
56	McBee silty clay loam	Fine-silty, mixed, mesic Cumulic Ultic Haploxerolls	Slight	96.4

Map Unit	Name	Taxonomic Classification	Soil Erosion Hazard	Total Map Unit Acres
58C	McCully gravelly loam, 2 to 15 percent slopes	Fine, mixed, mesic Typic Haplumbrepts	Slight	11.7
58D	McCully gravelly loam, 15 to 30 percent slopes	Fine, mixed, mesic Typic Haplumbrepts	Moderate	310.5
58E	McCully gravelly loam, 30 to 50 percent slopes	Fine, mixed, mesic Typic Haplumbrepts	Severe	245.2
58F	Kinney-Klickitat complex, 20 to 50 percent north slopes	Fine-loamy, mixed, mesic Andic Haplumbrepts	Moderate	114
58G	Kinney-Klickitat complex, 50 to 70 percent north slopes	Fine-loamy, mixed, mesic Andic Haplumbrepts	Severe	193.6
59F	Kinney-Klickitat complex, 20 to 50 percent south slopes	Fine-loamy, mixed, mesic Andic Haplumbrepts	Moderate	61.4
59G	Kinney-Klickitat complex, 50 to 70 percent south slopes	Fine-loamy, mixed, mesic Andic Haplumbrepts	Severe	202.2
5D	Aschoff cobbly loam, 5 to 30 percent slopes	Loamy-skeletal, mixed, mesic Andic Haplumbrepts	Moderate	41.6
5E	Aschoff cobbly loam, 30 to 60 percent slopes	Loamy-skeletal, mixed, mesic Andic Haplumbrepts	Severe	21.1
60E	Klickitat-Harrington complex, 3 to 30 percent slopes	Loamy-skeletal, mixed, mesic Typic Haplumbrepts	Slight	365.1
61F	Klickitat-Harrington complex, 30 to 50 percent north slopes	Loamy-skeletal, mixed, mesic Typic Haplumbrepts	Moderate	58.1
63	Malabon silty clay loam	Fine, mixed, mesic Pachic Ultic Argixerolls	Slight	81.1
64	Malabon variant loam	Medial, mesic Typic Dystrandepts	Slight	1.1
65F	Newanna-Rock outcrop complex, 60 to 90 percent slopes	Medial-skeletal, frigid Alic Haplocryands	Severe	368.9
67	McBee silty clay loam	Fine-silty, mixed, mesic Cumulic Ultic Haploxerolls	Slight	179.1
69	Pits	0	Not rated	3.2
69B	Minniece silty clay loam, 0 to 8 percent slopes	Fine, mixed, mesic Typic Umbraqualfs	Slight	46.2

Map Unit	Name	Taxonomic Classification	Soil Erosion Hazard	Total Map Unit Acres
6F	Aschoff-Brightwood complex, 60 to 90 percent slopes	Loamy-skeletal, mixed, mesic Andic Haplumbrepts	Severe	0.8
70D	Moe gravelly loam, 3 to 25 percent slopes	Medial, frigid Andic Haplumbrepts	Moderate	472
70F	Moe gravelly loam, 25 to 50 percent slopes	Medial, frigid Andic Haplumbrepts	Severe	238.2
72D	Ritner cobbly silty clay loam, 5 to 30 percent slopes	Clayey-skeletal, mixed, mesic Dystric Xerochrepts	Moderate	46.2
73	Newberg fine sandy loam	Coarse-loamy, mixed, mesic Fluventic Haploxerolls	Slight	9.1
74H	Ochrepts, very steep	Frigid Ochrepts	Not rated	285.5
76B	Salem silt loam, 0 to 7 percent slopes	Fine-loamy over sandy or sandy-skeletal, mixed, mesic Pachic Ultic Argixerolls	Slight	208.2
77B	Salem gravelly silt loam, 0 to 7 percent slopes	Fine-loamy over sandy or sandy-skeletal, mixed, mesic Pachic Ultic Argixerolls	Slight	21.1
78D	Saum silt loam, 15 to 30 percent slopes	Fine, mixed, mesic Typic Xerumbrepts	Severe	60.3
80	Pits	0	Not rated	0.9
80C	Springwater loam, 8 to 15 percent slopes	Fine-loamy, mixed, mesic Typic Xerochrepts	Moderate	4.1
80D	Springwater loam, 15 to 30 percent slopes	Fine-loamy, mixed, mesic Typic Xerochrepts	Moderate	72.3
80E	Springwater loam, 30 to 60 percent slopes	Fine-loamy, mixed, mesic Typic Xerochrepts	Severe	68.1
81D	Quartzville silt loam, 2 to 25 percent slopes	Fine, mixed, mesic Andic Haplumbrepts	Moderate	476.4
82F	Quartzville silt loam, 25 to 50 percent north slopes	Fine, mixed, mesic Andic Haplumbrepts	Severe	330.6
84	Wapato silty clay loam	Fine-silty, mixed, mesic Fluvaquentic Haplaquolls	Slight	11

Map Unit	Name	Taxonomic Classification	Soil Erosion Hazard	Total Map Unit Acres
85D	Wilhoit-Zygore gravelly loams, 5 to 30 percent slopes	Fine-loamy, mixed, frigid Andic Haplumbrepts	Slight	45.2
86G	Rock outcrop-Orthents complex, steep	0	Not rated	2240
87	Salem gravelly silt loam	Fine-loamy over sandy or sandy-skeletal, mixed, mesic Pachic Ultic Argixerolls	Slight	567.8
90F	Witzel-Rock outcrop complex, 50 to 75 percent slopes	Loamy-skeletal, mixed, mesic Lithic Ultic Haploxerolls	Severe	0.5
91D	Alspaugh clay loam, 15 to 30 percent slopes	Clayey, mixed, mesic Humic Hapludults	Moderate	27.2
92	Sifton variant gravelly loam	Sandy-skeletal, mixed, mesic Andic Xerumbrepts	Slight	0.2
94E	Zygore gravelly loam, 30 to 60 percent slopes	Loamy-skeletal, mixed, frigid Andic Haplumbrepts	Severe	246.2
95E	Zygore-Wilhoit gravelly loams, 30 to 60 percent slopes	Loamy-skeletal, mixed, frigid Andic Haplumbrepts	Severe	169.8
96E	Highcamp very gravelly loam, 30 to 60 percent slopes	Medial-skeletal, frigid Typic Haplocryands	Severe	1505.4
97F	Highcamp-Rock outcrop complex, 50 to 90 percent slopes	Medial-skeletal, frigid Typic Haplocryands	Severe	14.2
98D	Highcamp-Soosap complex, 5 to 30 percent slopes	Medial-skeletal, frigid Typic Haplocryands	Moderate	325
99E	Kinzel-Divers complex, 30 to 60 percent slopes	Medial-skeletal, frigid Typic Haplocryands	Moderate	14.8
Ad	Alluvial land	Mesic Xerofluvents	Not rated	696.7
Ca	Camas gravelly sandy loam	Sandy-skeletal, mixed, mesic Fluventic Haploxerolls	Slight	78.9
CLD	Cumley silty clay loam, 2 to 20 percent slopes	Clayey, mixed, mesic Typic Palehumults	Moderate	1372.8
Cm	Cloquato silt loam	Coarse-silty, mixed, mesic Cumulic Ultic Haploxerolls	Slight	994.5

Map Unit	Name	Taxonomic Classification	Soil Erosion Hazard	Total Map Unit Acres
HEE	Henline extremely stony sandy loam, 6 to 30 percent slopes	Loamy-skeletal, mixed Entic Cryumbrepts	Slight	62.7
HEF	Henline extremely stony sandy loam, 30 to 55 percent slopes	Loamy-skeletal, mixed Entic Cryumbrepts	Moderate	401.4
HEG	Henline extremely stony sandy loam, 55 to 80 percent slopes	Loamy-skeletal, mixed Entic Cryumbrepts	Moderate	1325.2
HRD	Horeb loam, 2 to 20 percent slopes	Fine-loamy, mixed, mesic Typic Haplumbrepts	Moderate	4295.8
HSC	Horeb gravelly silt loam, gravelly substratum, 0 to 15 percent slopes	Fine-loamy, mixed, mesic Typic Haplumbrepts	Slight	1605.4
HSE	Horeb gravelly silt loam, gravelly substratum, 15 to 35 percent slopes	Fine-loamy, mixed, mesic Typic Haplumbrepts	Moderate	1299.1
HTD	Hullt clay loam, 2 to 20 percent slopes	Fine-loamy, mixed, mesic Typic Xerumbrepts	Moderate	400.1
HTE	Hullt clay loam, 20 to 30 percent slopes	Fine-loamy, mixed, mesic Typic Xerumbrepts	Severe	15.2
HTF	Hullt clay loam, 30 to 60 percent slopes	Fine-loamy, mixed, mesic Typic Xerumbrepts	Severe	30.8
JoB	Jory silty clay loam, 2 to 7 percent slopes	Clayey, mixed, mesic Xeric Palehumults	Slight	10.8
KCD	Kinney cobbly loam, 2 to 20 percent slopes	Fine-loamy, mixed, mesic Andic Haplumbrepts	Slight	27.6
KCF	Kinney cobbly loam, 20 to 50 percent slopes	Fine-loamy, mixed, mesic Andic Haplumbrepts	Moderate	4078.1
KCG	Kinney cobbly loam, 50 to 70 percent slopes	Fine-loamy, mixed, mesic Andic Haplumbrepts	Severe	7129.7
MaA	McAlpin silty clay loam, 0 to 3 percent slopes	Fine, mixed, mesic Cumulic Ultic Haploxerolls	Slight	380.7
MaB	McAlpin silty clay loam, 3 to 6 percent slopes	Fine, mixed, mesic Cumulic Ultic Haploxerolls	Slight	29.8
Mb	McBee silty clay loam	Fine-silty, mixed, mesic Cumulic Ultic Haploxerolls	Slight	0.3

Map Unit	Name	Taxonomic Classification	Soil Erosion Hazard	Total Map Unit Acres
McB	McCully clay loam, 2 to 7 percent slopes	Fine, mixed, mesic Typic Haplumbrepts	Slight	34
McC	McCully clay loam, 7 to 12 percent slopes	Fine, mixed, mesic Typic Haplumbrepts	Slight	167.6
McD	McCully clay loam, 12 to 20 percent slopes	Fine, mixed, mesic Typic Haplumbrepts	Moderate	151.5
McE	McCully clay loam, 20 to 30 percent slopes	Fine, mixed, mesic Typic Haplumbrepts	Moderate	30.6
MmE	McCully very stony clay loam, 2 to 30 percent slopes	Fine, mixed, mesic Typic Haplumbrepts	Slight	2.8
MUE	McCully clay loam, 2 to 30 percent slopes	Fine, mixed, mesic Typic Haplumbrepts	Moderate	2157
MUF	McCully clay loam, 30 to 50 percent slopes	Fine, mixed, mesic Typic Haplumbrepts	Severe	3289.8
MUG	McCully clay loam, 50 to 70 percent slopes	Fine, mixed, mesic Typic Haplumbrepts	Severe	5712.8
MYB	Minniece silty clay loam, 0 to 8 percent slopes	Fine, mixed, mesic Typic Umbraqualfs	Slight	2373
NeB	Nekia silty clay loam, 2 to 7 percent slopes	Clayey, mixed, mesic Xeric Haplohumults	Slight	456.3
NeC	Nekia silty clay loam, 7 to 12 percent slopes	Clayey, mixed, mesic Xeric Haplohumults	Moderate	70.2
NeD	Nekia silty clay loam, 12 to 20 percent slopes	Clayey, mixed, mesic Xeric Haplohumults	Moderate	114.7
NsF	Nekia very stony silty clay loam, 30 to 50 percent slopes	Clayey, mixed, mesic Xeric Haplohumults	Severe	114.2
Nu	Newberg fine sandy loam	Coarse-loamy, mixed, mesic Fluventic Haploxerolls	Slight	326.4
Nw	Newberg silt loam	Coarse-loamy, mixed, mesic Fluventic Haploxerolls	Slight	6.7
PITS	Pits	0	Not rated	9.1

Map Unit	Name	Taxonomic Classification	Soil Erosion Hazard	Total Map Unit Acres
Sa	Salem gravelly silt loam	Fine-loamy over sandy or sandy-skeletal, mixed, mesic Pachic Ultic Argixerolls	Slight	2.1
St	Sifton gravelly loam	Medial over sandy or sandy-skeletal, mixed, mesic Typic Melanoxerands	Slight	98.1
Sy	Stony rock land	0	Not rated	435.3
W	Water	0	Not rated	35.6
Wa	Waldo silty clay loam	Fine, mixed, mesic Fluvaquentic Endoaquolls	Slight	530.7
Wc	Wapato silty clay loam	Fine-silty, mixed, mesic Fluvaquentic Endoaquolls	Slight	12.7
WHE	Whetstone stony loam, 3 to 25 percent slopes	Loamy-skeletal, mixed, frigid, ortstein Typic Haplocryods	Not rated	7.6
WHF	Whetstone stony loam, 25 to 55 percent slopes	Loamy-skeletal, mixed, frigid, ortstein Typic Haplocryods	Not rated	1054.3
WHG	Whetstone stony loam, 55 to 75 percent slopes	Loamy-skeletal, mixed, frigid, ortstein Typic Haplocryods	Not rated	4135.3

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

Appendix D – Supporting Geologic Hazards Information

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

I. Figures and Photos

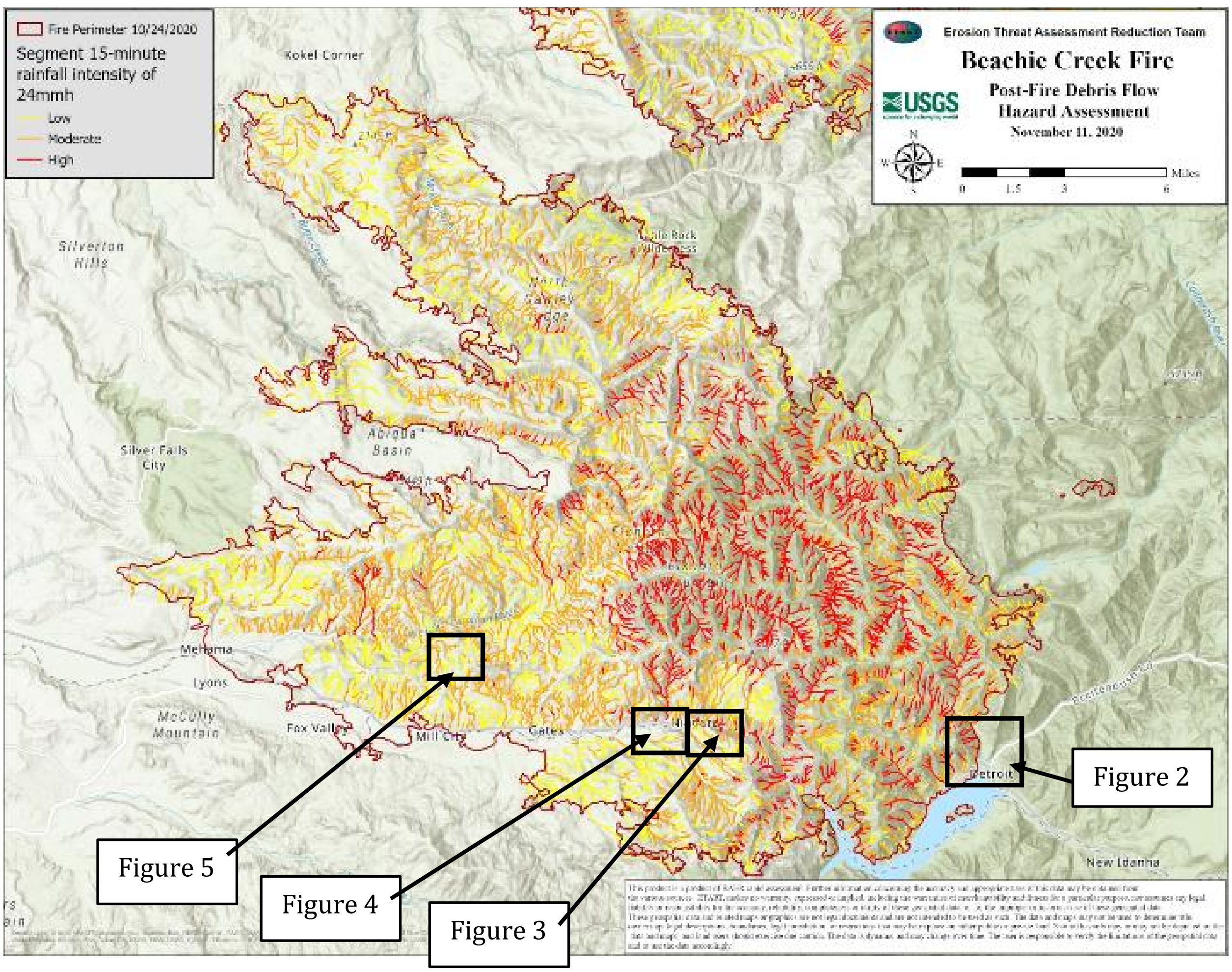


Figure 1: The map displays estimates of the combined relative debris flow hazard. These predictions are made at the scale of the drainage basin, and at the scale of the individual stream segment. Estimates of combined hazard are based upon a design storm with a peak 15-minute rainfall intensity of 24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

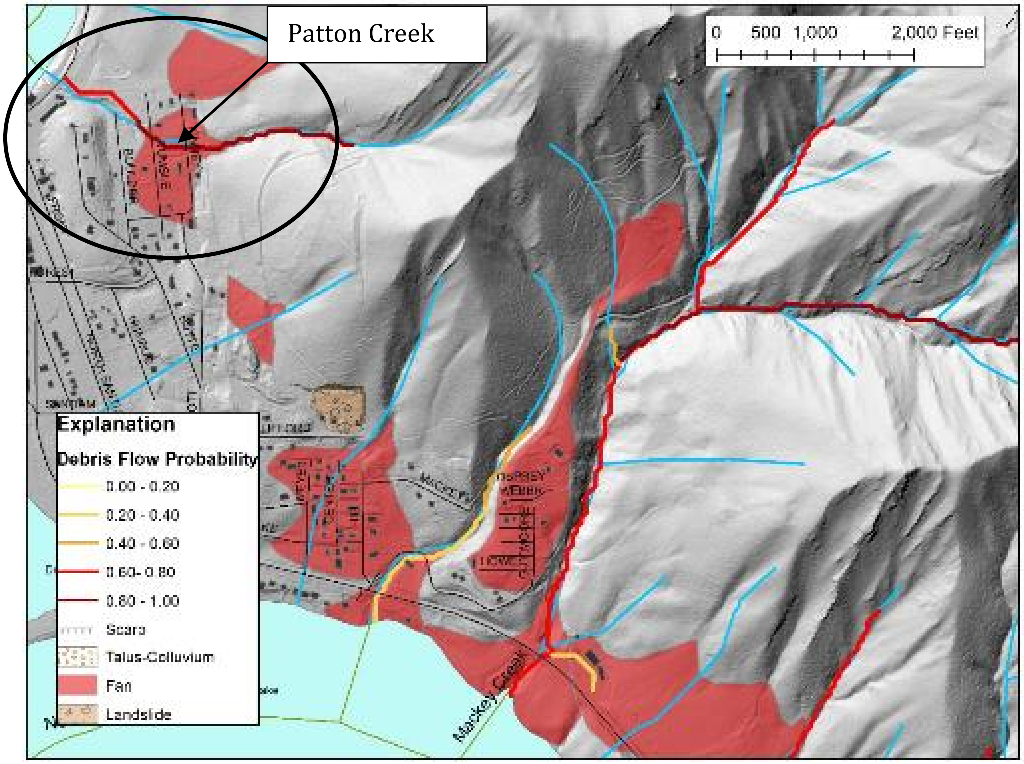


Figure 2: Town of Detroit buildings and infrastructure at potential landslide risk. Map includes USGS debris flow hazard channels and DOGAMI SLIDO debris flow fans (deposit) and landslide areas. Potentially high hazard emanating from Patton Creek drainage area into neighborhood built on fan deposits.

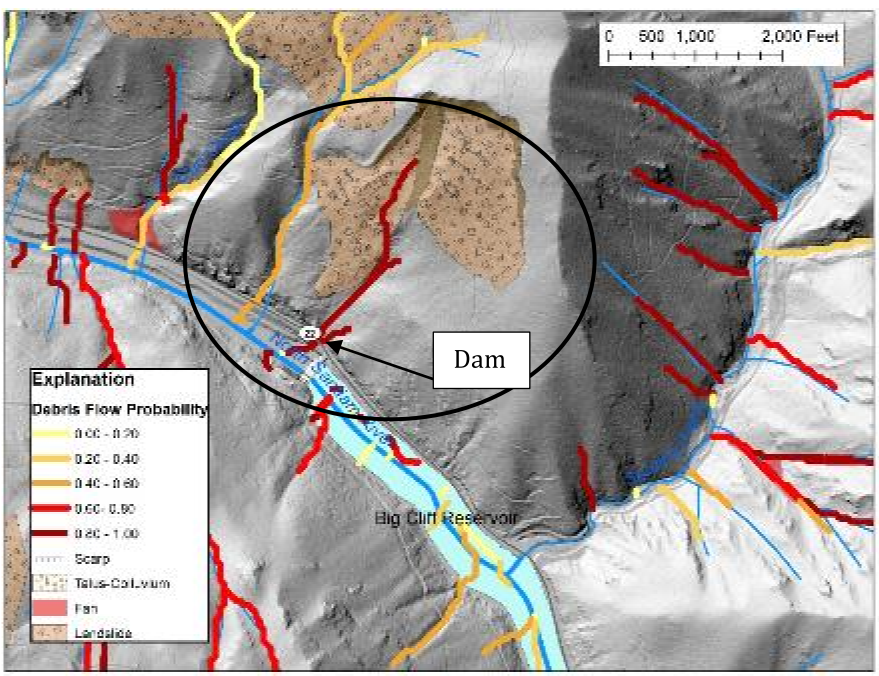


Figure 3: Big Cliff Dam facility and OR22 highway at risk. Includes USGS debris flow hazard channels and DOGAMI SLIDO debris flow fans (deposit) and landslide areas. Potentially high hazard emanating from unnamed drainage above dam facility and highway.

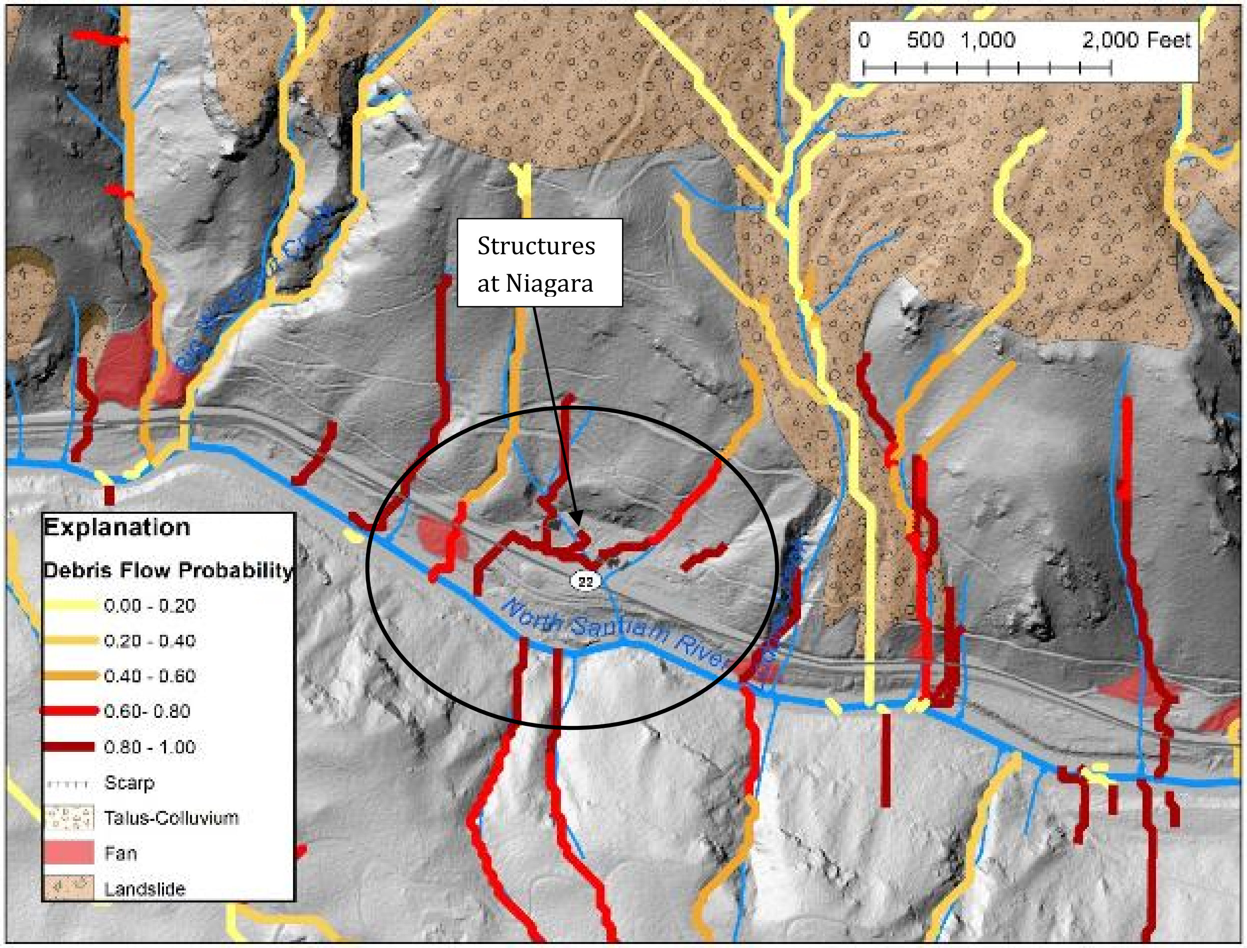


Figure 4: Map of the buildings and infrastructure at risk in the area of Niagara. Includes USGS debris flow hazard channels and DOGAMI SLIDO debris flow fans (deposit) and landslide areas. Potentially high to very high hazard emanating from creek drainage area into neighborhood built below steep channels.

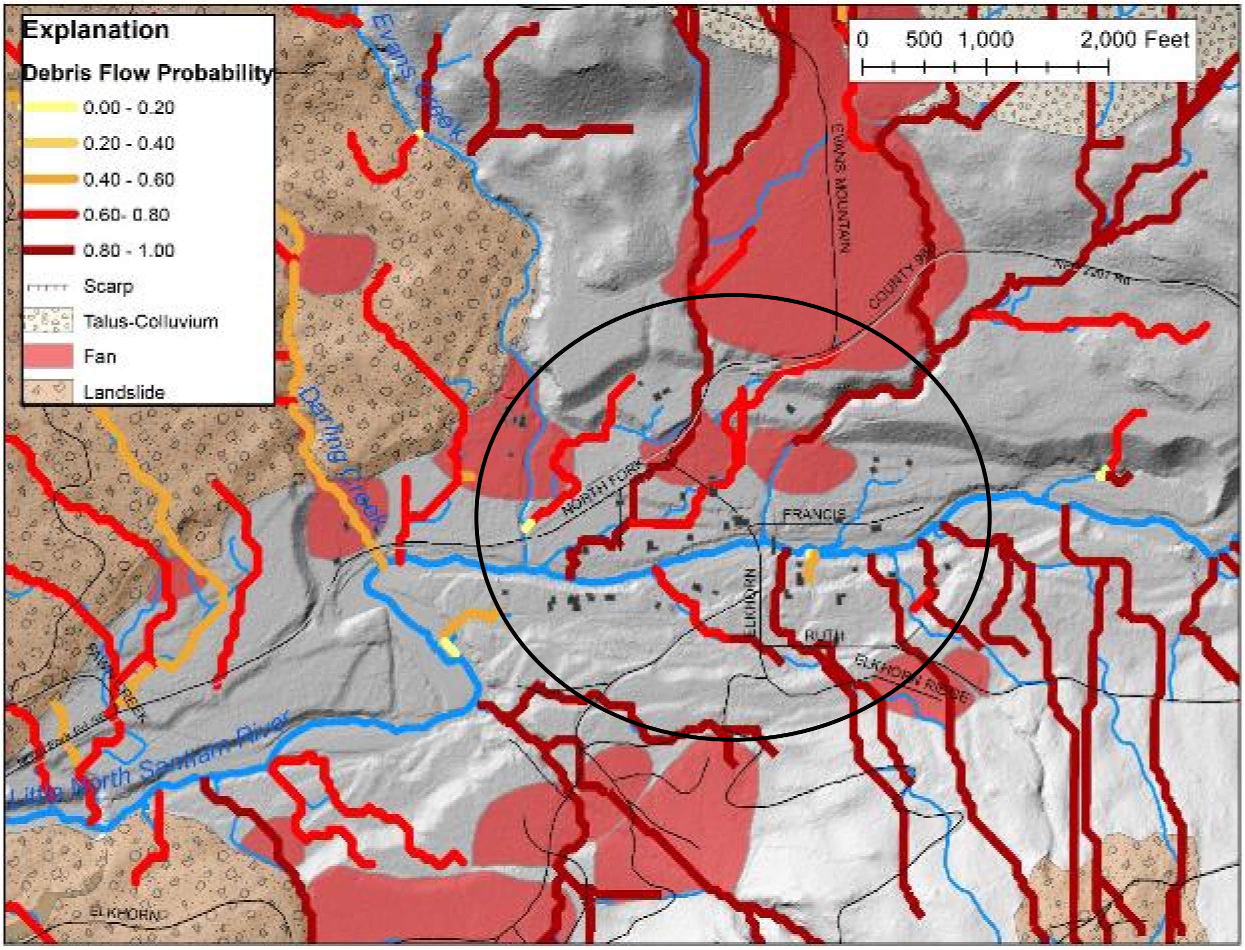


Figure 5: Map of community of Elkhorn along the Little North Santiam River. Buildings and infrastructure at moderate to high risk from debris flows and landslides. Includes USGS debris flow hazard channels and DOGAMI SLIDO debris flow fans (deposit) and landslide areas. Potentially high to very high hazard emanating from creek drainage area into neighborhood built below steep channels.

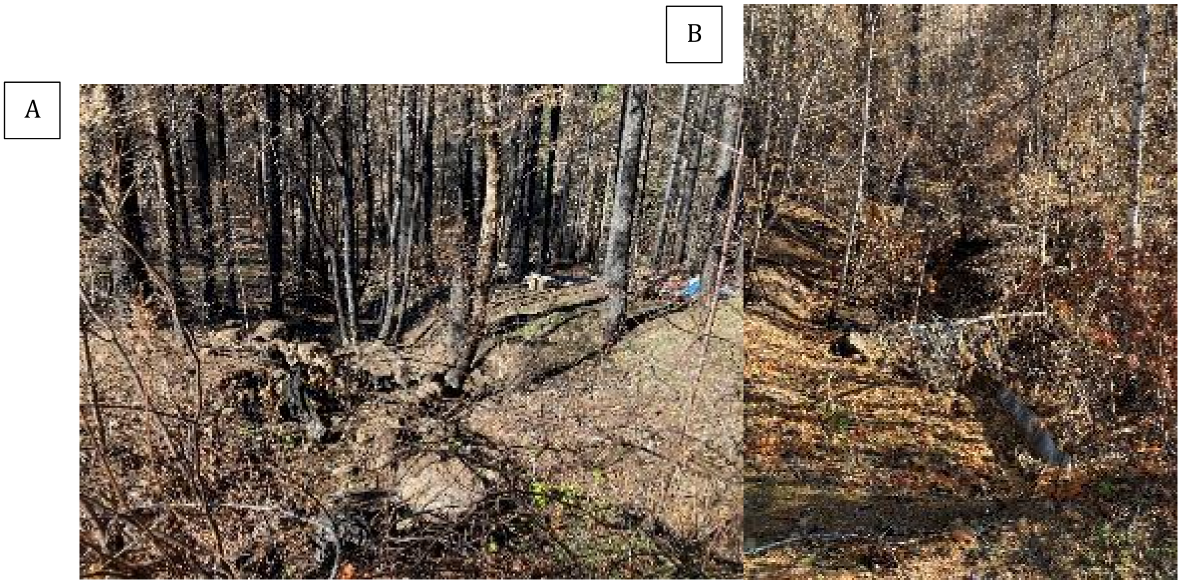


Photo 1: (A) Patton Creek at Kinney Ave. in Detroit looking downstream. (B) Patton Creek looking upstream. Refer to Figure 2 above for location. Patton Creek flows diagonally across Detroit neighborhood and has potentially a high hazard emanating from the burned drainage above the neighborhood.

Photo 2: (A) Big Cliff Dam facility and Steep channel above facility and OR22 with loose bedload material and wood debris. Refer to Figure 3 above. Potentially high hazard emanating from unnamed drainage above dam facility and highway.

Photo 3: Detroit Lake State Park entrance off OR22. In the watershed in the background was burned by the fire. Just off the right side is one of the channels emanating from this watershed which is unburned. Debris flows form in the burned upper watershed and can rapidly travel downstream through channels that are not burned. This channel runs very close to the campground host sites and the visitor center. The state park is located on an alluvial fan deposits which was formed by many debris flow over time.

Photo 4: Rockfall hazards along North Fork Road (Marion County). Steep burned slopes on all roads in the fire area should be monitored. The vegetation of the slopes that was keeping the rocks on the slope is now gone. Loose rocks will fall during and after rain events.

Photo 5: Clear cut slopes in the burned area along North Fork Road (Marion County). This area is an active landslide called "Bear Trap" landslide. During this assessment, drilling crews were installing slope inclinometers near the road to monitor landslide movement. A Hilfiker type retaining wall is supporting the toe of this slope below the road. Post fire debris flow hazard is high on this slope. Landslide activity would be expected to increase 3-5 years or sooner post-fire.

Photo 6: 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
City of Detroit	Community	landslide, Debris flow	high	Possible	Major	High	monitor, warning signs, weather alert
▪ Eastern portion of town on past debris flow deposits. Of the roughly 300 buildings, roughly 60 are on past DF fan deposits. DF tend to happen repeatedly in the same drainages. USGS data show moderate to high on combined channel dataset.							
Mackey Creek, City of Detroit, OR22	Community + ODOT	landslide, Debris flow	high	Possible	Major	High	monitor, warning signs, weather alert
▪ Channel runs through the eastern part of town and crosses OR22.							
Detroit Lake Rec. Area - State Park	State	Debris flow	high	Possible	Major	High	warning signs, weather alert
▪ Channel runs next main entrance and could support a debris flow, large burned basin above, Park built on fan deposits, deposition zone, camp host sites and visitor center could be impacted							
Detroit Reservoir	USACE	Debris flow	moderate	Possible	Minor	Low	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
▪ Many channels enter Detroit Lake, all with the potential to carry debris flows, however, due to the size of the lake a landslide induced tsunami produced from an event is unlikely to damage the concrete dam structure.							
Detroit Dam & Facilities	USACE	Debris flow	moderate	Possible	Moderate	Intermediate	monitor, warning signs, weather alert
▪ Small channel on south side of dam could impact structure, channel is small and unlikely to damage the dam. Dam facility buildings below the dam are at risk from debris flow out of channels on the north side of the canyon.							
Sardine Creek/OR22, Big Cliff Reservoir	USACE, ODOT	Debris flow	High	Possible	Minor	Low	None
▪ Sardine Creek is a very large channel and is likely to absorb any debris flows which flow into it, Debris Flow from the creek are unlikely to reach OR22 and Big Cliff Reservoir. Sediment will affect reservoir capacity.							
Mayflower Creek/OR22, Big Cliff Reservoir	USACE, ODOT	Debris flow	High	Possible	Minor	Low	None
▪ High debris flow potential, deeply incised channel, unlikely to affect OR22 and Big Cliff Reservoir.							

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
OR22	ODOT	rockfall, Debris flow, landslides	Varies on location	Likely	Major	Very 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.							

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) *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; All other species *without* signs or symptoms

Failure Indicator		Failure Potential		
		Imminent	Likely	Low
	Live trees in Armillaria or Heterobasidion root disease centers *Armillaria* spp. (p. 60) *Heterobasidion* 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
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

Failure Indicator		Failure Potential		
		Imminent	**Likely**	**Low**
	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 Douglas-fir, pine, cedar, juniper, or larch with >75% of the bole cross-sectional area burned 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 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
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 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

Failure Indicator		**Failure Potential**		
		Imminent	**Likely**	**Low**
	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) *Echinodontium tinctorium*	Trees with multiple, large (≥6 in. wide) conks; 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
	Red ring rot conks, white speck (p. 90) *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; 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; ≤2 large conks within a 3-ft.-long trunk cylinder; 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* (pouch conk) (p. 95) *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

Failure Indicator		Failure Potential		
		Imminent	**Likely**	**Low**
Tops and Branches	Forked or multiple tops or stems (p. 97)	Trees with any fork associated with open cracks, decay, or conks* (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* (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* (tops are low FP, not the whole tree unless fork is at the base)
	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)

Failure Indicator		Failure Potential		
		Imminent	**Likely**	**Low**
	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
	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. 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	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	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) Communities between Lyons and Detroit	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.	Minor to Moderate - Environmentally persistent contaminants that are introduced to waterways may have multigenerational impacts. Other more transient chemcicals will likely have impact on 1-2 generations within the area of exposure	Low to High	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 singificant 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
Fish Ladder (Salmon Falls, Little North Fork Santiam River)	Debris blocking fish passage	Likely - Little North Fork watershed experienced a high level of burn severity and vegetation mortality. Likely a lot of this debris will 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

Values at Risk (VAR) Table

Value	Probability of Damage or Loss	Magnitude of Consequence	Hazard to Value	Treatment Recommendation	Treatment Justification
OR-22 highway corridor, and associated infrastructure, including transmission lines	Possible to likely, depending on location	Moderate to major, depending on location	Intermediate to very high	Road maintenance, storm patrol, debris flow and rockfall signage, hazard tree removal, log erosion barriers, additional treatments may be necessary	Highly trafficked highway. Sections of windy road with no shoulder have steep hills abutting hwy. Likely occurrence of damage from debris and erosion.
Private property and infrastructure along North Fork Rd	Possible	Moderate	Intermediate	Inform stakeholders of risk and storm monitoring	Mosaic of high and moderate soil burn severity may result in increased sediment and debris.
Private property and Infrastructure below outlet of Stout Creek	Possible	Moderate	Intermediate	Inform stakeholders of risk and storm monitoring	Ground conditions within the Stout Creek drainage could not be field verified. SBS models indicate 2.69 magnitude increase in hillslope soil loss.
Private property and infrastructure along South Butte Creek Rd	Possible	Minor to Moderate	Low to intermediate	Inform stakeholders of risk and more detailed assessments of hazards. Engineering teams to inspect culverts and other road infrastructure	Increased sediment flows could lead to sediment and debris depositing on private property.

Value	Probability of Damage or Loss	Magnitude of Consequence	Hazard to Value	Treatment Recommendation	Treatment Justification
Roads, trails, and public access within Santiam State Forest	Possible	Minor to moderate	Low to intermediate	Damage assessment and hazard tree removal in areas trafficked by public. Temporary closure until risk can be mitigated.	Protecting public safety in highly trafficked areas is paramount.
Private property and infrastructure in Niagara	Possible	Moderate	Intermediate	Inform stakeholders of risk and more detailed assessments of hazards within the Niagara Creek drainage	Niagara Creek's drainage path is along Niagara Heights Rd and 3rd Street SE, in the path of private residences.
Road infrastructure on industrial private lands	Likely	Moderate	High	Storm patrol and road maintenance	Hillslope treatments not effective at mitigating erosion on steep slopes common within impacted areas.
Niagara Park, Packsaddle Park, Minto County Park, and other public parks and river access within fire	Possible	Minor	Low	Hazard tree removal, road inspection and maintenance if necessary	Protecting public safety in highly trafficked areas is paramount.
Private property an infrastructure in Mill City	Possible	Moderate	Intermediate	Inform stakeholders of risk and more detailed assessments of hazards that may present threats in the drainages above Mill City	Mosaic of soil burn severity may result in sediment and debris flow towards the northern section of Mill City.
Soil Productivity on Industrial Private Lands	Likely	Minor	Low	Natural Recovery	Hillslope treatments are not effective enough on steep slopes to be economically viable in impacted areas.