Riverside Fire

Erosion Threat Assessment/Reduction Team (ETART) Summary Report

December 2020

FEMA

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Executive Summary

This report summarizes a rapid characterization of post-fire conditions resulting from the Riverside 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 Riverside 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 Riverside Fire perimeter. Critical values include human life and safety; improved properties/assets such as roads, bridges, buildings and water systems; important natural resources (soil productivity, water quality and municipal water sources, habitats for wildlife and fish); and cultural resources. Threats that exist or are recognized to amplify in a post-fire setting include accelerated soil erosion and hillslope water runoff that results in increased sediment transport, high stream flows, floods or debris flows; landslides and rock fall; hazard trees; mobilization of hazardous materials; and expansion of invasive or noxious plants. This report does not include an assessment of water quality and water systems that provide safe, clean drinking water. Refer to the ETART Water Quality/Drinking Water Supply Resource Report for information on post-fire threats and response actions for these values.

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

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

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

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

1. Overview

1.1. Burned Area Characterization

- Fire Name: Riverside
- State: Oregon
- Fire Number: OR-MHF-00859
- County: Clackamas
- Date Fire Started: September 8, 2020
- Date Fire Contained: October 31, 2020 (estimate, ICS-209 dated 10/25/2020)
- Suppression Cost: $21,000,000 (estimate, ICS-209 dated 10/25/2020)

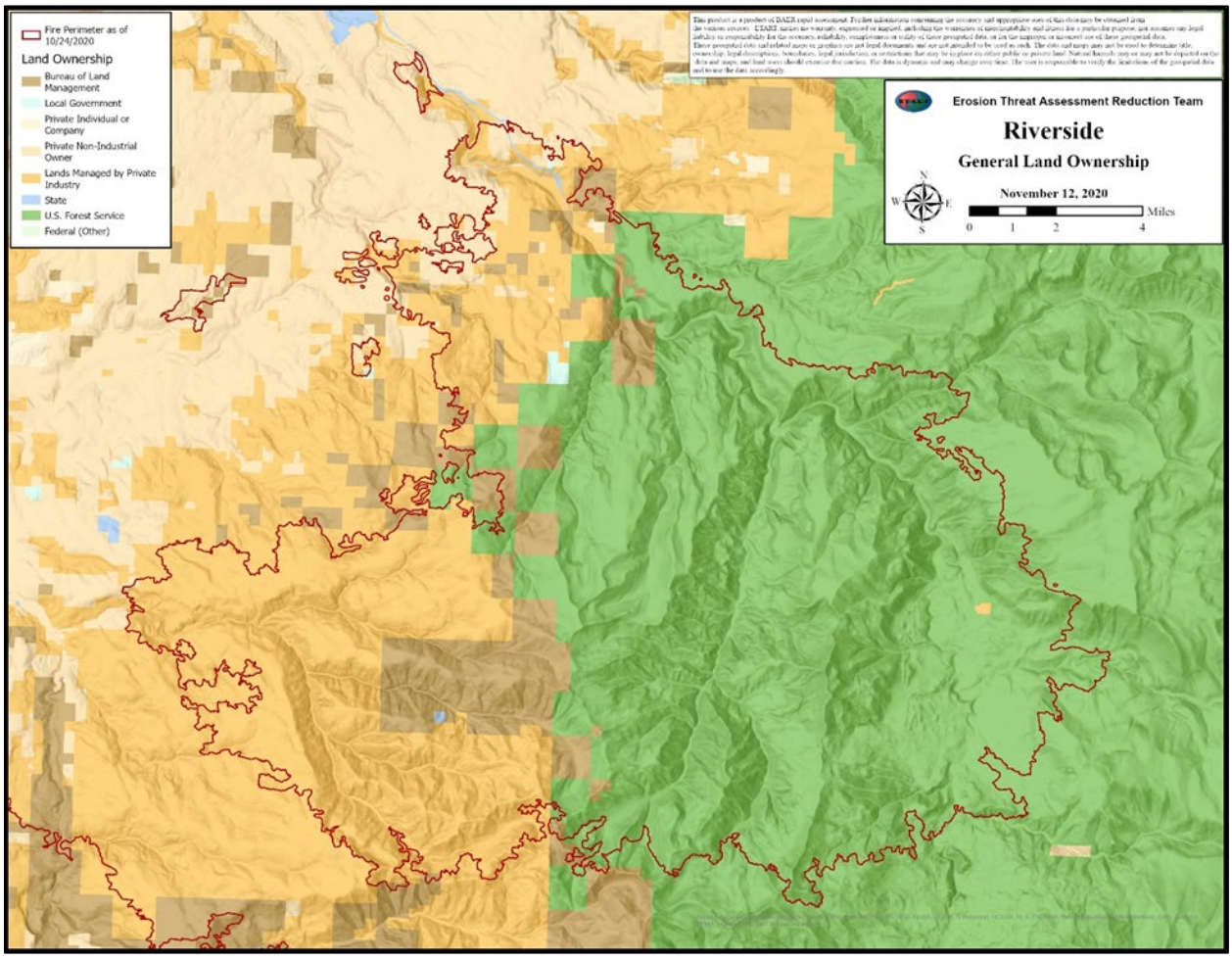

Figure 1. Land Ownership - Riverside Fire

The Riverside Fire was detected on September 8, 2020, southeast of Estacada, Oregon, in the Clackamas River drainage on the Mt. Hood National Forest. Driven by high winds the fire rapidly grew to about 40,000 acres, with fire suppression crews reporting extreme fire behavior that included running crown fire, torching and long-range spotting. By September 9th the fire had burned 112,000 acres, strong easterly winds and low humidity pushed the fire 17 miles west down the Clackamas River corridor and on to surrounding private lands. Erratic winds expanded the fire perimeter on all sides with the largest growth to the east and southeast, causing a 10,000-foot smoke column when plumes from the Riverside and Beachie Creek Fires converged. Heavy smoke conditions grounded air operations until a weather system changed conditions on September 18th. The fire burned approximately 138,151 acres, primarily within the Clackamas and Molalla River basins and destroyed an estimated 57 homes, damaged 10 other residences and 186 minor structures. Multiple land ownerships are affected by the fire, including the Mt. Hood National Forest, BLM, and commercial and private forest lands under authority of the State of Oregon Department of Forestry (ODF). (Figure 1 and Table 1.)

Table 1. Riverside Fire Total Acres Burned – 138,151 (based on post-fire analysis perimeter)

Ownership	Acres	Sq.Mi.	Percent
Local	242	<1	<1%
Private	42,059	123	30%
State	149	<1	<1%
Tribal	0	0	0%
Federal	95,701	141	69%
Total	**138,151**[a]	**216**	

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

1.1.1. CLIMATE

Climate in the Clackamas and Molalla River basins is characterized by warm, dry summers, while winters are wet and mild at lower elevations. Most of the precipitation is generated by frontal storms falling between October and May in the form of light- to moderate-intensity rainfall and winter snow accumulations, and averages 72 inches annually. Higher elevation locations in the headwaters of the Clackamas River basin develop snowpack and melt out in spring. Peak flows within the Molalla River basin are largely rainfall dominated, with little storage due to minimal seasonal snowpack or groundwater contributions. Rain-on-snow events are common, typically occurring from November through January, and range in their magnitude of hydrologic responses. While flash flooding and debris flows are rare in this area, there is evidence of previous past debris flows, and these events are more likely due to the post-fire lack of effective ground cover. This may result in hazardous conditions within and downstream of the burned area in the winter and spring months.

1.1.2. GEOLOGIC TYPES

The burned area lies entirely within the Western Cascades Physiographic Province, which is characterized by older volcanic rocks, generally steep slopes, and large ancient landslide deposits. The bedrock geology is primarily comprised of Pliocene to Quaternary igneous extrusive rocks: basalt, basaltic andesite, dacite, and rhyolite. 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. Burned areas associated with the Riverside Fire are mostly confined to the North Fork Molalla River drainage downstream to the confluence with the Molalla River. 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.

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 have varying amounts of rock fragment content across the region. Typically, the skeletal soils are associated with glacial deposits and colluvial deposits. Rock outcrops and scree slopes occur on steeper areas and mountain slopes. Soils with andic soil properties are common throughout the region. The landscape in this region feature steep hillslopes having a natural tendency to slough material; this is due to the soil textures, steep slopes, geology and climate.

1.1.4. VEGETATION TYPES

Three major forest stand association groups within the fire perimeter include the following forest types: western hemlock, mountain hemlock, and silver fir. Grand fir, white fir, and other types compose a small portion of the burn area.

- Western hemlock series occurs at lower elevations in the southwest portion of the forest and the overstory is normally dominated by Douglas fir with regular disturbance such as fire. The understory is western hemlock with a variety of shrub ground cover types depending on elevational and moisture gradients as with all groups.

- Pacific silver fir series occurs in cooler and more moist conditions at a higher elevation than the Western Hemlock Series. The overstory of this series is also usually the dominant overstory species outside of disturbance with pacific silver fir and shrub types dominating the understory.

- Mountain hemlock series occurs in cool moist conditions at upper elevations on both sides of the Cascade.

1.1.5. WATERSHEDS (6TH LEVEL HYDROLOGIC UNITS)

The Riverside Fire burned within the Middle Clackamas and Upper Molalla watersheds (HUC10). The Riverside Fire also burned areas within the headwaters of the Molalla River of the Upper Molalla watershed within the Table Rock Wilderness area. The fire area was largely confined to federal lands in the Mt. Hood National Forest; however, impacts from burned areas are likely to elevate risk to critical values downstream on private and county lands.

Table 1. Affected Watersheds (6th Level Hydrologic Unit Name)

Watershed Name	Total Acres	Acres Burned	% Burned
Canyon Creek	10,713	1,710	16.0
Cedar Creek-Molalla River	8,419	58	0.7
Cot Creek-Oat Grove Fork Clackamas River	14,171	2,298	16.2
Dead Horse Canyon Creek	8,987	6,680	74.3
Dubois Creek-Clackamas River	12,636	1,383	10.9
Farm Creek-Collawash River	16,326	329	2.0
Fish Creek	29,807	24,773	83.1
Headwaters Milk Creek	10,244	301	2.9
Helion Creek-Clackamas River	11,719	10,571	90.2
Lower Eagle Creek	22,359	263	1.2
Lower Hot Springs Fork	18,272	119	0.7
Lower North Fork Molalla River	7,116	4,108	57.7
Middle Clear Creek	21,813	1,916	8.8
North Fork Clackamas River	20,638	665	3.2
Pine Creek-Molalla River	23,952	6	0.0
Pot Creek-Clackamas River	22,961	174	0.8
Roaring River	27,309	1,595	5.8
South Fork Clackamas River	17,656	14,595	82.7
Table Rock Fork	23,227	319	1.4
Three Lynx Creek-Clackamas River	31,546	22,075	70.0

Watershed Name	Total Acres	Acres Burned	% Burned
Trout Creek-Molalla River	15,678	1,450	9.3
Upper Clear Creek	12,247	7,391	60.3
Upper North Fork Molalla River	19,699	15,876	80.6
Woodcock Creek	8,200	1,029	12.5

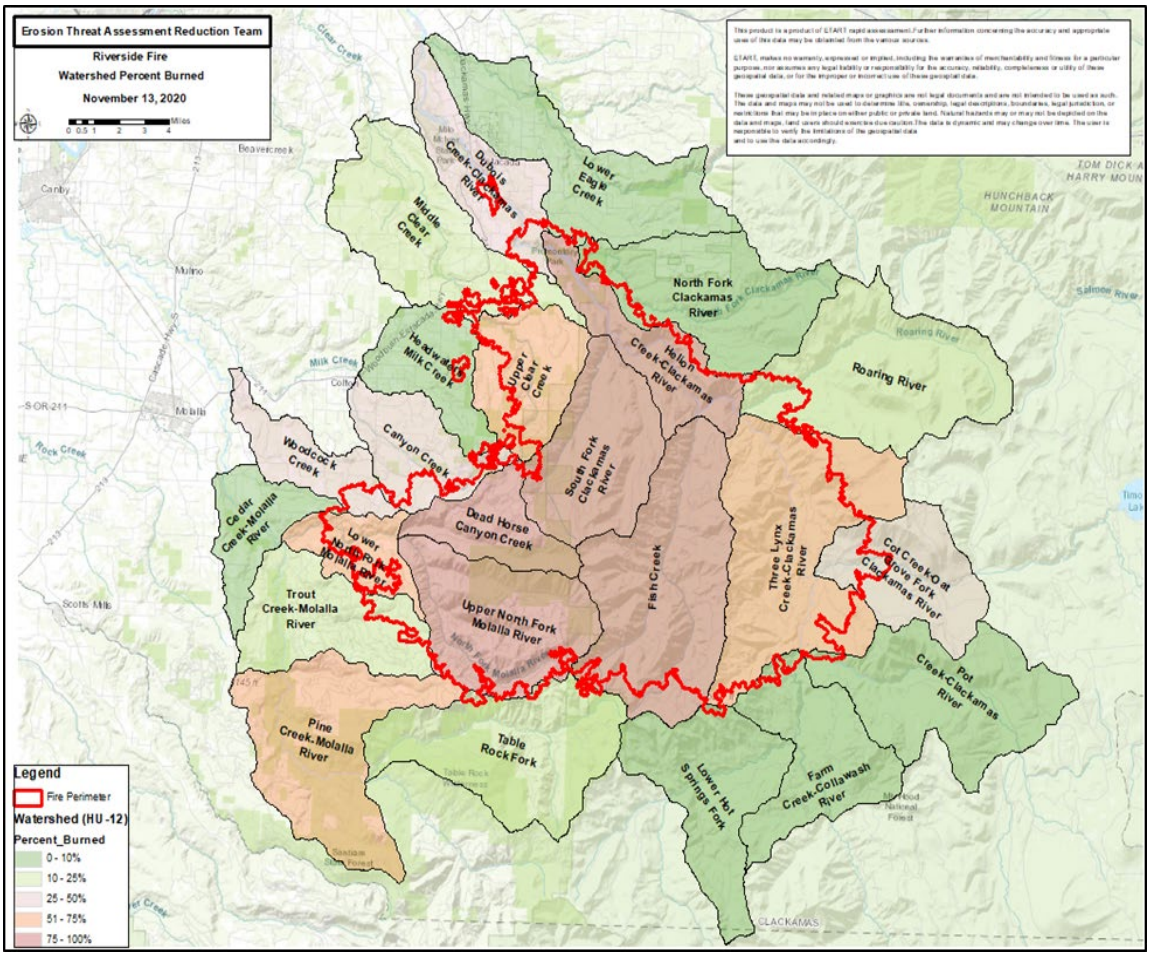

Figure 2. Watersheds Percent Area Burned - Riverside Fire

Table 4. Road Miles by Ownership Designation within Fire Perimeter

Owner Designation	Miles[a]
Bureau of Land Management	63.8
County Route	8.4
Forest Service	271.6
Other State Route (e.g., State Park)	3.2
Private Route	58.5
ODF State Forestry Route	0.3
State Highway	22.0
Unknown	320.6
Total Miles	748.4

Table 5. Miles of Stream within Fire Perimeter by Type

Stream Type	Miles by Type[b]
Perennial	302
Intermittent	621
Ephemeral	0
Other	53

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 Riverside 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	16,934	12%	14,902	88%	14	<1%	2,017	12%	0	0
Moderate	55,126	40%	37,406	68%	39	<1%	17,658	32%	23	<1%
Low	47,624	35%	31,058	65%	140	<1%	16,305	34%	122	<1%
Unburned	18,295	13%	12,274	67%	68	<1%	5,946	32%	7	<1%
Total	**137,979**		**95,640**		**261**		**41,926**		**152**	

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 commonly unburned or had lower burned severity. Soils within the watersheds and riparian areas had heterogenous vegetation and higher moisture content which contributed to lower burn-related soil impacts in those areas. Moderate and high soil burn severity was consistently observed on south facing slopes. South facing slopes are generally drier and therefore ground fuels were less resistant to fire.

1.2.2. WATER-REPELLENT SOIL (ACRES)

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

1.2.3. SOIL EROSION INDEX

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

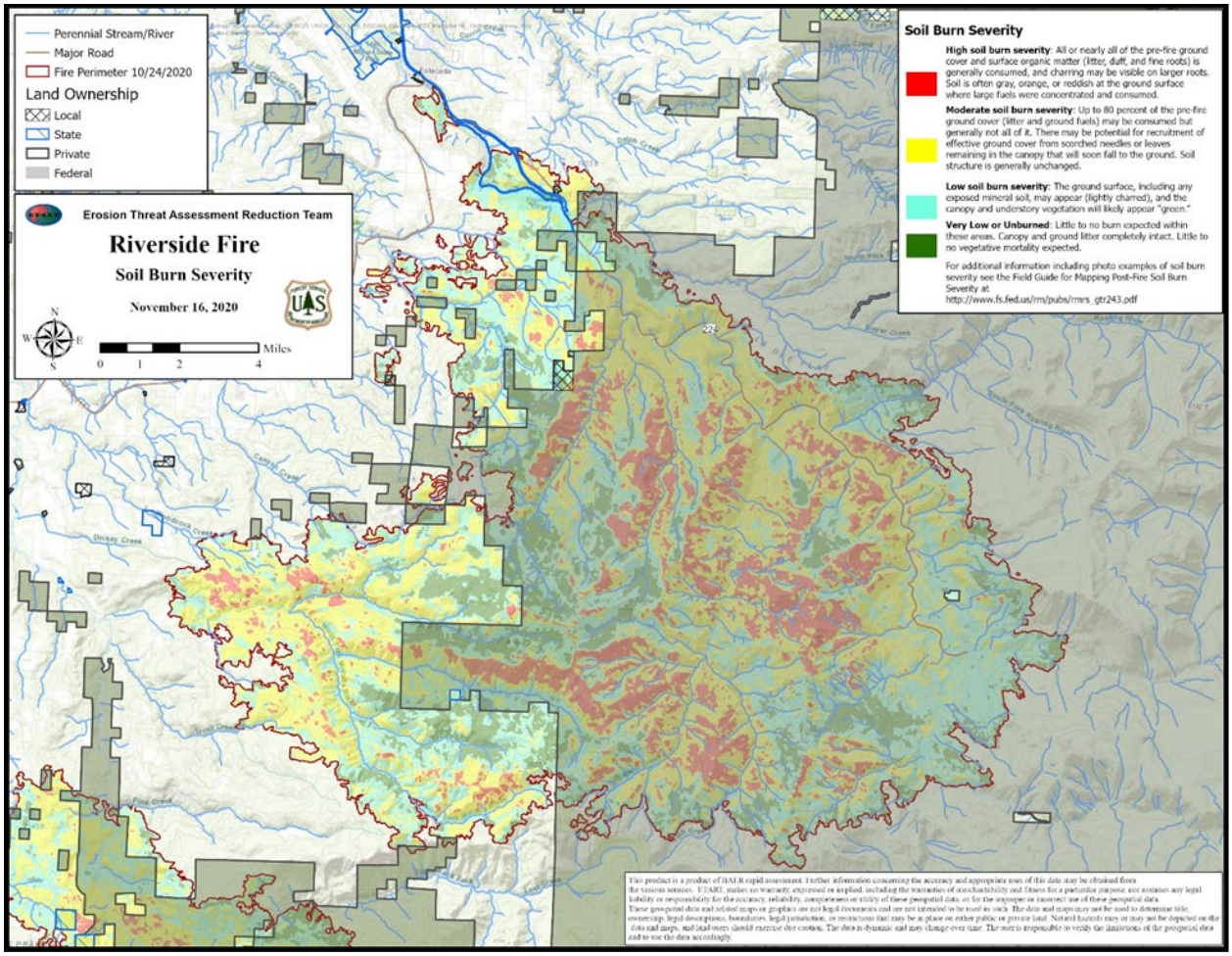

Figure 3. Soil Burn Severity – Riverside Fire

Figure 4. displays the spatial distribution and acres by SEI for the area burned by Riverside 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.

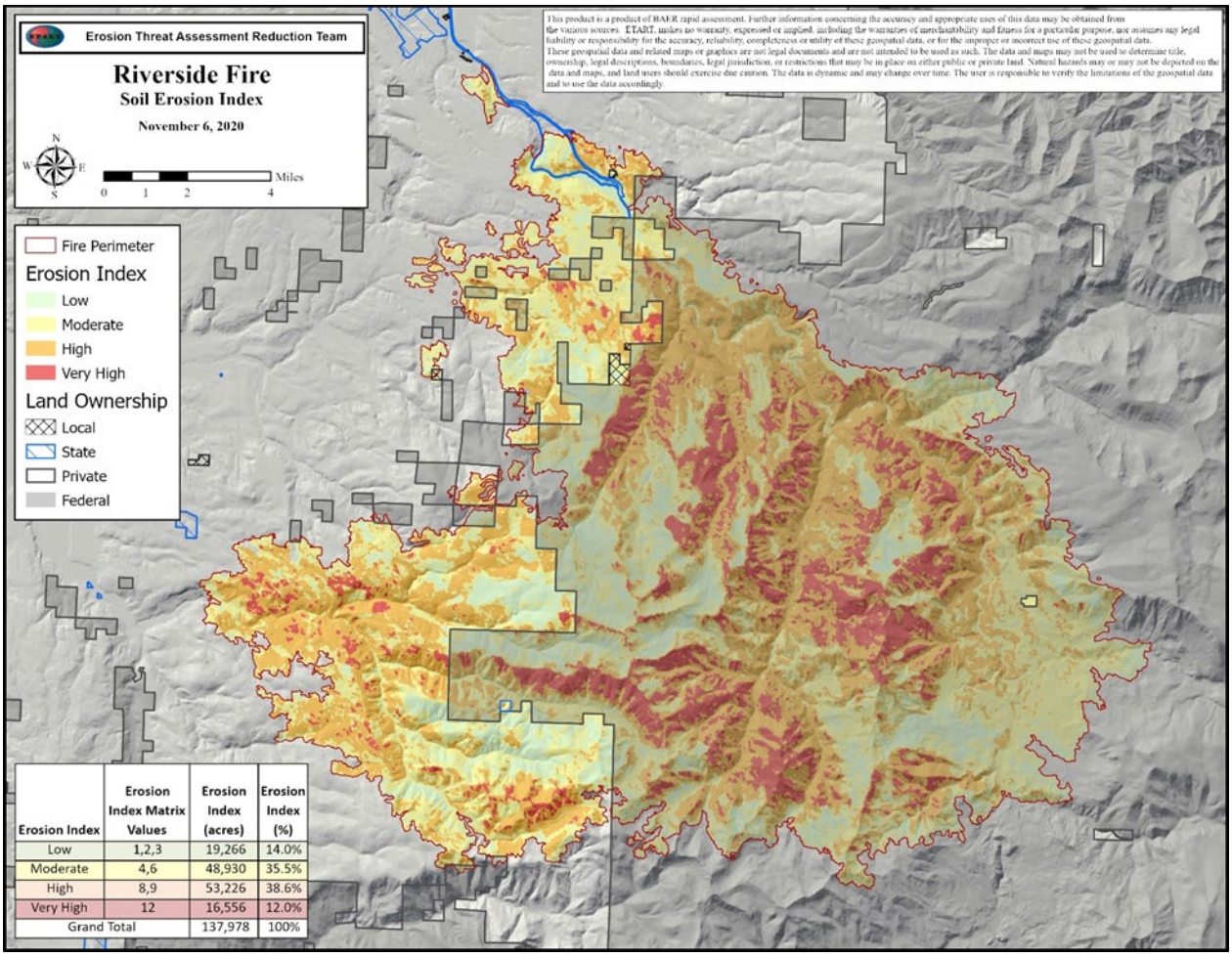

Figure 4. Soil Erosion Index – Riverside Fire

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 6 drainages across 3 subwatersheds (HUC12) were evaluated. Each drainage was modeled for post-fire response using the SBS data and compared to unburned conditions. The estimated increase in soil loss per watershed unit area ranges from no change up to 0.5 tons/acre the first year after the fire, averaging about 0.3 tons/acre increase across the burned watersheds of interest. On average there is roughly a 3-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 North Fork Molalla River where approximately 43% of the watershed has burned. The North Fork Molalla River above Molalla River has a predicted increase of 1.2 times the pre-fire peak flow magnitude. The slightly elevated peak flow response is due to the large portion burned acreage classified as moderate or high soil burn severity in a relatively smaller watershed. In contrast, the increase in magnitude of post-fire peak flows in the other poursheds is 1.1 times the pre-fire peak flow for the 5-year recurrence interval (Figure 5).

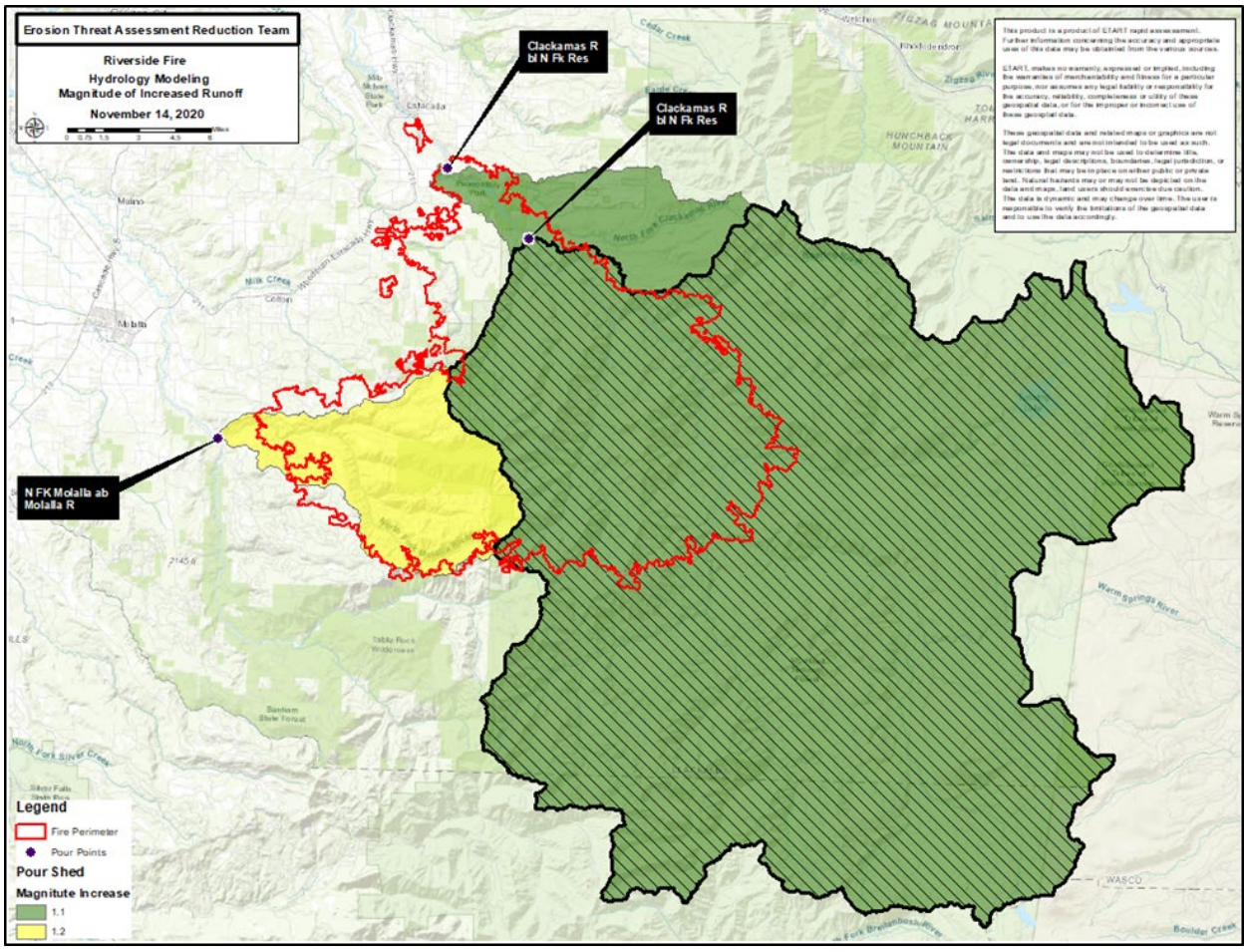

Figure 5. Watershed Response in Runoff Magnitude Increase – Riverside Fire

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

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

Figure 6. Risk Matrix

2.1. Human Life and Safety Summary

2.1.1. HAZARD TREES

Very High risk to **motorists along roadways, people near structures, and visitors and employees at recreation areas** from falling of hazardous trees killed or damaged by fire. These locations have large numbers of dead and fire damaged trees (>75% basal area (BA) mortality). There is "Very High" risk (likely, major) in areas having 1-75% BA mortality, as well. Although there are generally lower numbers of dead and fire damaged trees, the threat will result in major consequences to human life and safety (and property). An estimated 72 road miles have moderate to high levels of basal area mortality, where fire-killed or damaged trees are within falling distance to reach a road on state and private lands. There are over 265 acres of hazard trees within the 100' buffer surrounding all structures. There are 133 structures in areas that suffered 50% or greater basal area mortality. Another 170 structures are in areas that suffered less than 50% basal area mortality. Specific areas of concern noted by the ETART the OR-224 corridor.

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.

High risk to **highway users along OR-224 corridor** from getting struck or stranded/ blocked by debris. Road 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.

Recommendations: Road maintenance, storm patrol, debris flow and rockfall signage, hazard tree removal. Additional survey may be needed to identify appropriate treatments.

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

Low risk to **life and safety on the North Fork Reservoir, Silver Fox RV Park and the town of Dodge** from debris flows. Debris flow channels enter the reservoir and lead to the RV park and town but

have limited probability for occurrence. The RV park is on a large deep landslide which has some potential to reactivate.

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.

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

Very High risk to **boaters and swimmers on North Fork Reservoir and at Silver Fox RV park** from hazard trees, floating debris and additional "stringers" (woody slightly below the water surface). Debris is already observed in the water and volumes are expected to increase.

Recommendations: Fell hazard trees that would impact human lives, implement closure of facilities until trees can be assessed and mitigated. Install hazard warning signs at boat launch locations (docks, marinas, river access) of risks from debris threats; remove debris as appropriate. Downed trees pose a significant life to human life and safety when boating or swimming, whether in rivers (North Fork Molalla and North Fork Clackamas) or on the North Fork Reservoir. Outreach and education, communication and coordination with Marine Safety Board.

2.2. Property Summary

High risk to **Get N Go Promontory Marina Estacada and North Fork Reservoir Dam** from woody debris build up. Large woody debris already evident in marina; expected increase in wood recruitment due to burned trees. Low velocity flow in reservoir to move floating debris.

Recommendations: Increased frequency for inspections to identify debris removal.

High risk to **landowners and property (assets)** due to shift in fire regimes and fire severity from establishment and expansion of fire-adapted noxious weeds on or near rural and residential properties. The area impacted by the Riverside fire has had significant selection pressure to shift plant populations toward fire-adapted species. The homes, churches, and businesses destroyed in the residential areas of the Riverside fire demonstrate the potential consequences of not maintaining defensible space.

Recommendations: Outreach and education to impacted communities of Colton, Dodge, Dickie Prairie, Elwood, Estacada, Highland, Molalla and Springwater on Firewise planning to promote defensible space. Survey for areas with high fuel loads and regeneration potential for flammable weed species. Identify programs for noxious weed surveys, treatments and monitoring, focusing on highly flammable species such as Scotch broom, gorse and Himalayan blackberry.

High risk to **OR-224 highway corridor and associated infrastructure, including transmission lines and powerhouse (State)** from sediment and debris deposition into ditch lines and on to road surfaces. Steep slopes and decreased ground cover make sediment mobilization, in potentially substantial amounts, likely in some locations. Highway is a main access route with heavy traffic, and damage would likely be substantial and result in temporary loss of use.

Recommendations: Road maintenance, storm patrol, debris flow and rockfall signage, hazard tree removal, additional treatments may be necessary.

Intermediate risk to **boat launch infrastructure on North Fork Reservoir and at Silver Fox RV park** from hazard trees. While mostly low severity, secondary mortality could result in property damage or impact access to boat launch.

Recommendations: Fell hazard trees likely to impact infrastructure.

Intermediate risk to **private residences along the river** from sediment bulked flows impacting riverbanks with bank erosion of property boundaries along floodplain. While these properties are along the river, they are located downstream of burned area so debris and sediment may attenuate. More likely high flows will result in nuisance damage to property but not likely to impact structures.

Recommendations: Inform property owners and county emergency management of risk.

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.

Intermediate risk to **bridge on South Dickey Prairie Rd (County)** from sediment bulked flows and debris impacting bridge footings. Bridge is high above river surface and is below burned area, but some debris may reach bridge and could damage footings or abutments. Flood source area is N. Fork Mollala, primarily federal and industrial ownership.

Recommendations: Storm Patrol with equipment, as appropriate following precipitation events, to remove debris; and monitoring.

Intermediate risk to **bridge and nearby homes at South Dickey Prairie Rd and South Megan Ave** from woody debris build-up. High volume of tree mortality will contribute to increased woody debrisin channel that could in property damage or loss. 45.083715, -122.489072

Recommendations: Increased frequency for inspections to identify debris removal. Notify ODOT.

Intermediate risk to **road infrastructure on Industrial Private Lands** from sediment and debris deposition into road ditches and travel surfaces. Steep slopes and absence of post-fire ground cover make sediment mobilization likely, with impacted road drainage which may damage running surfaces or result in road failures.

Recommendations: Coordination with landowners.

Intermediate risk to **Oak Grove Powerhouse (PGE infrastructure, private)** from erosion, sediment and falling debris damaging powerhouse. Property is located within the Riverside fire boundary, below burned hillslopes with low to moderate erosion risk and moderate to high debris flow risk. Impacts to power infrastructure may result in moderate property damage as well as service interruptions to other users, including the light railway light system.

Recommendations: Inform power companies of potential threats to infrastructure and related service concerns.

Intermediate risk to **Faraday Powerhouse (PGE infrastructure, private)** from erosion, sediment and falling debris damaging powerhouse. Property borders Riverside fire and is located adjacent to low and moderate SBS areas. Impacts to power infrastructure may result in moderate property damage as well as service interruptions to other users.

Recommendations: Inform power companies of potential threats to their infrastructure and related service concerns.

Low risk to **Clackamas County Roads (Fall Creek Road, Hillockburn Road)** from increased erosion, sediment and water flow. The roads at risk within the Riverside Fire burned areas are located primarily within or below areas of low to moderate SBS. There is a future threat to travelers along the roads within the burned area due to the increased potential for culverts plugging with sediment or debris which could washout sections of the roads. With the loss of vegetation, normal storm frequencies and magnitudes can more easily initiate erosion on the slopes, and it is likely that this runoff will cover the roads or cause washouts at drainage facilities (culverts) or stream crossings. These events make for hazardous access to forest roads and put the safety of users at risk. See Appendix A for road treatment cost estimates.

Recommendations:

- Fall Creek Road – Storm proofing and storm inspection and response.
- Hillockburn Road - Storm proofing and storm inspection and response. Replace damaged culvert.

Road Treatments

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

Low risk to **property on the North Fork Reservoir, Silver Fox RV Park and the town of Dodge** from debris flows. Debris flow channels enter the reservoir and lead to the RV park and town but have limited probability for occurrence. The RV park is on a large deep landslide which has some potential to reactivate.

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 **fish ladder at North Fork Reservoir Dam** from hazard trees. While mostly low severity, secondary mortality could result in property damage.

Recommendations: Fell hazard trees likely to impact infrastructure.

2.3. Natural Resources Summary

2.3.1. SOIL AND WATER

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

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

2.3.2. FISH AND WILDLIFE HABITAT

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

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

High risk for contaminated **water quality that supports aquatic habitat for sensitive and T&E species** from burned debris. Runoff from burned buildings and vehicles (Job Corps/USFS facilities) containing hazardous wastes threatens aquatic habitats near wetlands, Dry Creek and the Clackamas River. A number of urban areas were subject to fire damage and are in proximity to waterways. Efforts to remove hazardous wastes are underway but in some instances surface runoff from rains has already occurred or will occur before wastes are removed. Environmentally persistent contaminants introduced to waterways may have multigenerational impacts. Other more transient chemicals will likely impact one to two generations within the area of exposure.

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

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

No treatment recommended.

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

No treatment recommended.

General Fish and Wildlife Recommendations

Early Seral Habitat near Habelt Road outside of Estacada. Assist landowner (Port Blakely) with reseeding to benefit deer and elk and provide soil stability in areas of moderate to high SBS. Timberlands experienced high vegetation mortality (76-100% BA) over a large area. Reseeding is known to have major benefits to early successional species as well as help reduce erosion and decrease susceptibility for expansion of invasive plants.

Early Seral Habitat near South Fork Clackamas River/Resort Road. Assist landowner with reseeding to increase forage for deer and elk forage and improve soil quality. These lands experienced moderate to high SBS and high vegetation mortality (76-100% BA) over a large area. Reseeding is known to have major benefits to early successional species as well as reduce soil erosion and decrease potential for expansion of invasive plants.

Maintain or Retore Aquatic Habitat Connectivity. Work with partners to identify priorities and options for fish passage at stream crossings; implement aquatic organism passage options when replacing burned/washed out culverts. Given scale of fires and the number of culverts on the landscape, it is

likely some culverts were or will be impacted. Restoring passage allows fish to access suitable habitat or refugia if primary habitats are impacted by post-fire events.

Riparian Habitat along Three Lynx Creek. Work with partners to revegetate and stabilize slopes to minimize erosion and runoff. from low to moderate SBS areas. High-value, sensitive amphibian species in this riparian habitat will likely benefit from erosion management and runoff prevention, which could benefit multiple sensitive species.

Intact Late Seral Habitat near Roaring River. Work with partners to encourage natural regeneration through carefully managed salvage logging practices that promotes standing dead wood and small open patches. The low to moderate SBS in this area creates favorable late seral conditions for sensitive species that retain or enhance positive habitat features.

Biodiversity Hotspot along Fish Creek. Work with partners to promote revegetation of native plant species to stabilize soil and limit invasive plant species. This is an area of high biodiversity with moderate to high SBS as well as high vegetation mortality. Reseeding would help soil stabilization and control invasive plant species, benefiting a variety of game and nongame species that use this river corridor. Consider alternative salvage logging practices to limit disturbance.

Sensitive Species Habitat in Rock Canyon. Work with partners to promote revegetation of native plant species to stabilize soil and limit invasive plant species. High quality habitat used by deer, elk, bear and sensitive species with moderate to high SBS and high debris flow probability. Revegetating and stabilizing this area to decrease erosion potential and control invasive species is expected to benefit multiple high priority and sensitive species.

Early Seral Habitat North Fork Molalla River. Work with partners to promote revegetation of native plant species to stabilize soil and limit invasive plant species. Timberlands experienced moderate to high SBS over a large area with habitat that supports black bear, Roosevelt elk and black-tailed deer. Reseeding is likely to have major benefits to early successional species as well as help with soil stability and controlling invasive plants.

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

Large Woody Debris (LWD). 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. Many of the rivers and streams have historically low levels of LWD. Maintain standing or dead trees within riparian areas could potentially reset the system and provide substantial long-term benefits in terms of creating suitable

habitat for aquatic and terrestrial species. As these trees enter streams and rivers, they create high quality habitat for salmonids.

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

Intact Late Seral Habitat adjacent to highly impacted LSR area at Dead Horse Canyon Creek. Work with partners to encourage natural regeneration, apply conservative salvage harvest practices and restrict motor vehicle access. Currently minimal disturbance in mostly intact late seral habitat is likely refugia for species displaced from adjacent highly impacted LSR. Standing dead wood and small open patches should benefit the sensitive species located in this area.

Sensitive Species Area - Whale Creek. Work with partners to revegetate with native plant species to stabilize soil and reduce potential for invasive species. Multiple sensitive aquatic species that occupy downstream habitats could benefit from stabilization measures. Slope stabilization activities could reduce high debris flow probability and also protect ongoing restoration projects.

Sensitive Species Areas - Worsted Creek and Fish Creek Divide. Work with partners to encourage natural regeneration and minimize additional disturbance. Low to moderate SBS area with habitat for sensitive species. Standing dead wood and small open patches from the fire create favorable late seral conditions for sensitive species.

Sensitive Species Area Wash Creek – Camelback. Work with partners to limit disturbance and promote passive restoration to decrease soil erosion and control invasive plant species. Habitat supports deer, elk and sensitive species with large areas affected by high SBS that could experience further impacts from salvage harvest and other disturbances. Consider revegetation, as needed, for soil stabilization and to control invasive species.

Sensitive Species Area - Clackamas Wilderness Area. Work with partner to encourage passive restoration of sensitive species habitat with high vegetation mortality. This area appears to be highly impacted by the fire and natural regeneration will take many years.

Late Seral Habitat in Roaring River Wilderness. Work with partners to promote retention of downed large woody debris for amphibian habitat. This is a wilderness area with habitat for sensitive species in LSR impacted by fire. Natural regeneration through passive restoration will take many years.

Biodiversity Hotspot - Lukens Creek. Work with partners to implement alternative salvage harvest practices that promote passive restoration in riparian areas. Sensitive species and habitats exist in area with low to moderate SBS located adjacent to high SBS lands. Implementing Discretionary salvage logging combined with minor riparian restoration could benefit multiple sensitive species in and adjacent to this area. Monitoring may be needed to determine impacts.

Biodiversity Hotspot - Station Creek. Work with federal partners to monitor sensitive species in this area using audio detectors and eDNA. Mostly low SBS across this area but impacts to habitat and species are unknown. Potentially opportunities to collaborate with on-going or planned monitoring activities.

2.3.3. NATIVE PLANT COMMUNITIES SUMMARY[1]

Very High risk to **multiple values (native plant communities, wildlife habitat, agriculture, timber production, water quality, etc.)** within and adjacent to the burned area from establishment and expansion of viable populations of local and state noxious weeds classified as priority for Early Detection and Rapid Response (EDRR). Emergent populations of Clackamas County "Priority" and "Containment" noxious weeds including Oregon "Class A" species have been documented on or near the burned area. The potential for expansion of noxious weeds are a significant ecological and economic concern. Emergent populations of local priority and containment weeds include orange hawkweed, gorse, slender false brome, Japanese knotweed, Bohemian knotweed and garlic mustard.

Recommendations: Early Detection and rapid response weed surveys and treatments using IPM based principles with the desired goal of eradication, and ongoing monitoring.

Very High risk to **multiple values (native plant communities, wildlife habitat, agriculture, timber production, water quality, etc.)** within and adjacent to the burned area from expansion of invasive plant species during fire rehabilitation, reforestation and salvage logging operations. The level of forest activities increases in numbers and intensity following the fire. There is increased potential for road systems to serve as dispersal vectors for spread of invasive plants to natural areas, nearby agricultural activities, timber salvage and reforestation operations, and residential areas. The vast amount of lands susceptible to expansion increase competition, thereby decreasing the ability for local plant communities to naturally regenerate.

Recommendations: Use equipment sanitation and prevention efforts to decrease the potential for spread of invasive and noxious weed seed. Conduct noxious weed surveys along road systems, and as needed treat noxious weeds using IPM based principles. Continue ongoing monitoring. To decrease the potential for spread of weed seed, a centrally located wash station could be installed to sanitize equipment during restoration, reforestation and salvage logging activities.

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

High risk to **native plant communities and wildlife habitat** from establishment and expansion of fire-adapted noxious weeds. Ground disturbance from fire and suppression operations resulting in bare increases susceptibility for invasive weeds, increasing competition and difficulty for local plant communities to return to pre-disturbance condition.

Recommendations: Noxious weed surveys and treatments using IPM-based principles, reseeding heavily disturbed areas and ongoing monitoring. Target survey and treatment activities in dozer lines, hand lines and drop point locations. Surveys in these areas require some expertise to include the identification of new weeds that may have been introduced during suppression activities.

High risk to **wetland habitats** from invasive plant establishment and suppression of regenerating native plants. Oregon Conservation Strategy Priority (OWEB-funded) wetland restoration projects are identified in the Riverside fire area, including the large inholding in upper area of the Mt Hood National Forest. Wetlands act as sinks on the landscape for both water-dispersed and wind-dispersed propagules. The threat of potential introduction from nearby weed populations is increased. Plants that persist within wetland areas tend to be well-adapted for wet conditions and noxious weeds that can establish in wetland systems have a tendency to proliferate. Reed canarygrass is a significant threat that has been identified in the burn zone.

Recommendations: Survey wetlands in and adjacent to areas with moderate to high SBS and treat noxious weeds adapted for wetland sites using effective IPM practices. Replant areas of high mortality and poor natural regeneration.

High risk to **grasslands and meadow habitats** from establishment of invasive plants and suppression of regenerating native species. Grasslands and meadow habitats are an Oregon Conservation Strategy Priority as intact habitats are generally rare. Local accounts of remnant prairie grasslands in the Willamette Valley is less than 1% of historic abundance, due in part to fire suppression, human development and noxious weed dispersal vectors. Forest meadows are the exception here and often contain pockets of rare plant assemblages. Due to degradation of the grasslands, they serve as noxious weed source populations to adjacent forest meadow habitats.

Recommendations: Noxious weed surveys, treatments using IPM based principles, reseeding of heavily disturbed areas and ongoing monitoring.

High risk to **rare, threatened and endangered (RTE) native plant species** from establishment and expansion of fire-adapted noxious weeds. Higher classes of SBS and vegetation mortality increase

the threat and dispersal of weed seed into sensitive areas. The RTE locations are priorities for population recovery efforts and experience a greater likelihood for invasive plant introduction from vehicles and personnel. RTE species loss can often be counted by individuals; seemingly small impacts to local plant communities can be significant.

Recommendations: Noxious weed surveys and treatments using IPM based principles with the desired goal of protecting and buffering sensitive species from the impacts and encroachment of noxious weeds. Surveys and treatments of invasive weeds should be targeted around sensitive species and undertaken in such a manner to prevent harming sensitive species. Particular focus should be on areas near dozer lines, hand lines and other suppression activity locations. Ongoing monitoring is needed.

Intermediate risk to **agricultural productivity and economic viability on designated "prime farmland" and "farmland of statewide importance"** from the establishment and expansion of agronomic noxious weeds. Disturbance from fire and suppression operations that result in bare and exposed soil increase the threat for spread of fire-adapted weeds. The presence of agronomic weeds on disturbed lands can impact local agricultural producers. Much of the existing agricultural lands are already actively managed for noxious weed. Increased pressure from weeds increases costs and reduces economic viability.

Recommendations: Noxious weed surveys, and treatments using IPM based principles, reseeding of heavily disturbed, ongoing monitoring.

Intermediate risk to **multiple values across the burned area (native plant communities, wildlife habitat, agriculture, timber production and soil/water quality)** from the spread of invasive plant species transported from contaminated gravel and rock sources. Two county-owned rock quarries are in the fire footprint that may provide aggregate for road and repair operations. Proliferation of noxious weeds in or around the county-operated quarries can lead to unintentional distribution of weed seed across the county. Quarry operations should be maintaining a weed-free yard, but staff resources may be limited in relation to the overall operations.

Recommendations: Prevent seed-contamination by transport of gravel and rock products through surveying and treating noxious weeds using IPM based principles in and around active quarry operations. Any weed contaminated materials should be rejected for redistribution. Equipment sanitation and prevent efforts should be taken to prevent spread of noxious weed seed. To prevent the spread of weed seed from contaminated vehicles, use a centrally located wash station to sanitize equipment used for distribution of gravel and rock products. Conduct ongoing monitoring.

Intermediate risk to **native plant communities in riparian areas** from establishment of invasive plants and suppression of regenerating native species. Riparian area restoration efforts are an Oregon Conservation Strategy Priority for threats from invasive weeds, including OWEB-funded projects in the public and private land matrix of Upper Molalla River, Lower Clackamas River and Middle Clackamas River. Past riparian restoration projects are limited on state and private lands. Native plants in riparian areas are generally more resilient to fire disturbance based on their proximity to water. Expected debris flows and increased sediment delivery are likely to increase disturbance and dispersal of noxious weeds.

Recommendations: Survey riparian corridors near areas with prior restoration efforts and treat noxious weeds using effective IPM practices. Replant areas with high mortality and poor natural regeneration. The OWEB-funded projects on the public and private land matrix of Upper Molalla River, Lower Clackamas River and Middle Clackamas River should be surveyed upstream and downstream for potential dispersal and transport of noxious weeds.

Intermediate risk to **oak habitats** from establishment of invasive plants and suppression of regenerating native species, threatening the success of local conservation and restoration efforts underway across the region. The Oak habitat in the Riverside fire area is already under pressure from noxious weeds and land development, but pockets of meaningful habitat persist. Oregon Conservation Strategy Priority recognizes Oak habitat as imperiled in the vicinity around the Riverside fire. Oak communities contain increasingly rare native plants assemblages in Willamette Valley and are a focus of regional and local conservation efforts. Oak habitat tends to benefit directly from fire by suppressing succession to fir-dominated stands, but oak-associated prairie forbs and grasses are detrimentally impacted by the co-occurrence of noxious weeds with fire.

Recommendations: Noxious weed surveys, treatments using IPM-based principles, reseeding of heavily disturbed with high burn severity and ongoing monitoring.

Intermediate risk to **ODF Habitat Conservation Areas** from establishment of invasive plants and suppression of regenerating native species. These conservation areas are priority for habitat improvements and experience a greater likelihood for noxious weed introduction from vehicles and personnel. Competition from noxious weeds result in the inability for local plant communities to regenerate.

Recommendations: Noxious weed surveys, treatments using IPM-based principles and ongoing monitoring. Focus survey and treatment efforts on established ODF Habitat Conservation Areas, with emphasis on riparian habitat function to protect conservation investments.

Low risk to **productivity of private forest land** from establishment and expansion of noxious weeds on economically important lands. Disturbance from fire and suppression operations resulting in bare soil increases the threat for spread of noxious weeds. The presence of noxious weeds can slow or suppress replant efforts and productivity of forestry operations. Much of the timbered lands are already under regular weed control. Increased pressure from noxious weeds can increases cost and reduces economic viability of operations.

Recommendations: Equipment sanitation and preventative efforts to prevent spread of noxious weed seed. Noxious weed surveys and treatments using IPM-based principles, reseeding of heavily disturbed areas and ongoing monitoring. The installation of a centrally located wash station could help prevent noxious weed introductions during fire rehabilitation, salvage logging and reforestation activities. Focus should be on preventing fire-adapted weeds from suppression activities on or adjacent to timber operations that may adversely impact timber production through direct competition or by altering the fire return intervals (i.e. false brome, gorse, scotch broom, blackberry, knapweeds).

Very Low risk to **old growth-late successional conifer forest** from establishment of invasive plants and suppression of regenerating native species. Old Growth and Late Successional Forest areas are an Oregon Conservation Strategy Priority. In the Riverside fire area these habitats tend to be isolated because of poor access, which decreases the threat of invasive plants being introduced. The old growth habitats on state and private lands are typically found in areas with typically high native plant cover. These areas should be resistant to invasion due to their competitive cover and lack of noxious weed propagule sources.

Recommendations: Limit access to old growth areas with high and moderate soil burn severity to minimize the potential for weed seed introduction into these areas. Survey these areas in subsequent years after vegetation has had a chance to rebound post-fire. Treat invasive weeds if new infestations are identified.

2.4. Cultural Resources Summary

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

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

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

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

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

3. Monitoring and Management Recommendations

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

3.1. Watershed Response and Hydrologic Analysis - Monitoring Recommendations

Modeling suggests that some watersheds affected by the Riverside 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.

Gaging stations are present in watersheds within and adjacent to the burned areas of the Beachie Creek and Riverside 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).

3.2. Geologic Hazards - Management Recommendations

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

3.3. Roads and Travel Routes - Management Recommendations

3.3.1. STORM INSPECTION AND RESPONSE

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

3.3.2. ROCK FALL, CHANNEL DEBRIS AND FLOOD MITIGATION ACTIONS

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

3.4. Fish/Aquatic Habitat - Management Recommendations and Monitoring

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

4. Riverside ETART Members

Riverside ETART

Team Member	Resource	Agency
Samuel Leininger	Botany (Weeds)	Clackamas Soil and Water Conservation District
Thomas Whittington	Engineering	Oregon Department of Forestry
Travis Wootan	Engineering	Clackamas County Road Department
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
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W. Terry Frueh	Hydrology	Oregon Department of Forestry
Anthony Collora	Soils	USDA Natural Resource Conservation Service

ETART Resource Leads

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Spencer Higginson	Hydrology	National Weather Service
Kyle Wright	Hydrology	USDA Forest Service
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ETART GIS Team

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Sharon Williams	FEMA
Joshua Keller	FEMA
Sean Carroll	US Army Corps of Engineers

Appendix A – Road Treatment Cost Estimates

Approximately 12.25 miles of roads within or adjacent to the fire perimeter were examined by ETART Engineering specialists. These roads are primarily the responsibility of Clackamas County road department, with a minority of other roads under the control or ownership of private forest landowners or residents. All roads are located on the western edge of the fire and within low SBS with a few segments bordered by moderate SBS. The roads evaluated pose little to no concern for failure due to the lack of high burn severity near them.

The identified risks to human life and safety and potential property damage are associated with threats from unmitigated hazard trees. The hazard trees falling onto a public road during heavy rainfall events increase the potential for culvert and road failures. These roads will require minimal action to maintain open and safe to all traffic.

Road Name	Description and Issues
Fall Creek Road Total Miles: 3.79 Miles in Burn: 0.42	▪ Paved, self-maintaining county road ▪ Provides access to numerous rural residential dwellings and private forestland, small tracts of BLM and USFS lands. ▪ Connections to additional county road: Michaels Road ▪ Needs: ditch cleaning, culvert inlet/outlet cleaning and storm monitoring. ▪ Values at Risk: property
Hillockburn Road Total Miles: 4.30 Miles in Burn: 3.02	▪ Paved, self-maintaining county road ▪ Provides access to numerous rural residential dwellings and private forestland, large tracts of BLM and USFS land. ▪ Connects to additional county roads: Habelt, Horner and Pederson Road ▪ Needs: culvert replacements, ditch cleaning, culvert inlet/outlet cleaning and storm monitoring. ▪ Values at Risk: property

Storm Inspection and Response

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.

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

Culvert Replacement

One existing culvert crossing on Hillockburn Road is damaged with moderate SBS drainages upslope. This culvert is currently functioning but is partially damaged on the inlet and may not provide full flow potential until repaired or replaced. If feasible and cost effective, replace the culvert to accommodate the expected post-fire flows. If culvert is not replaced, proceed with monitoring and ditch cleaning along the roads identified in the report. Other culverts in the burned area should be monitored to ensure full functionally through storm inspection and response.

Road Treatment Cost Estimates – Riverside Fire

Mobilization	Qty	Rate	Method	Unit	Total
Mobilization (total for all treatments)	1	$2,500	LSQ	lump sum	$3,500
Mobilization Total					**$3,500**

Culvert Replacement	Qty	Rate	Method	Unit	Total
Culvert Installation	1	$5,500	AQ	each	$2,500
Treatment Total					**$2,500**

Storm Inspection and Response	Qty	Rate	Method	Unit	Total
Monitoring crew (2 personnel)	3	$900	NA	day	$2,700
Vehicles, Equipment and Misc.	3	$300	NA	day	$900
Treatment Total					**$3,600**
Hillockburn Road Treatment Total					**$9,600**

Appendix B – Invasive Plant Species Treatment Design and Cost Estimates

The recommended treatments for each critical value and threat are described in below table. These recommendations are based on the information available at this time. Conditions in the burn area are not fully understood. As such, these recommendations should be modified as needed to address conditions in the field. Cost estimates for recommended treatments described here can be found in Table 8.

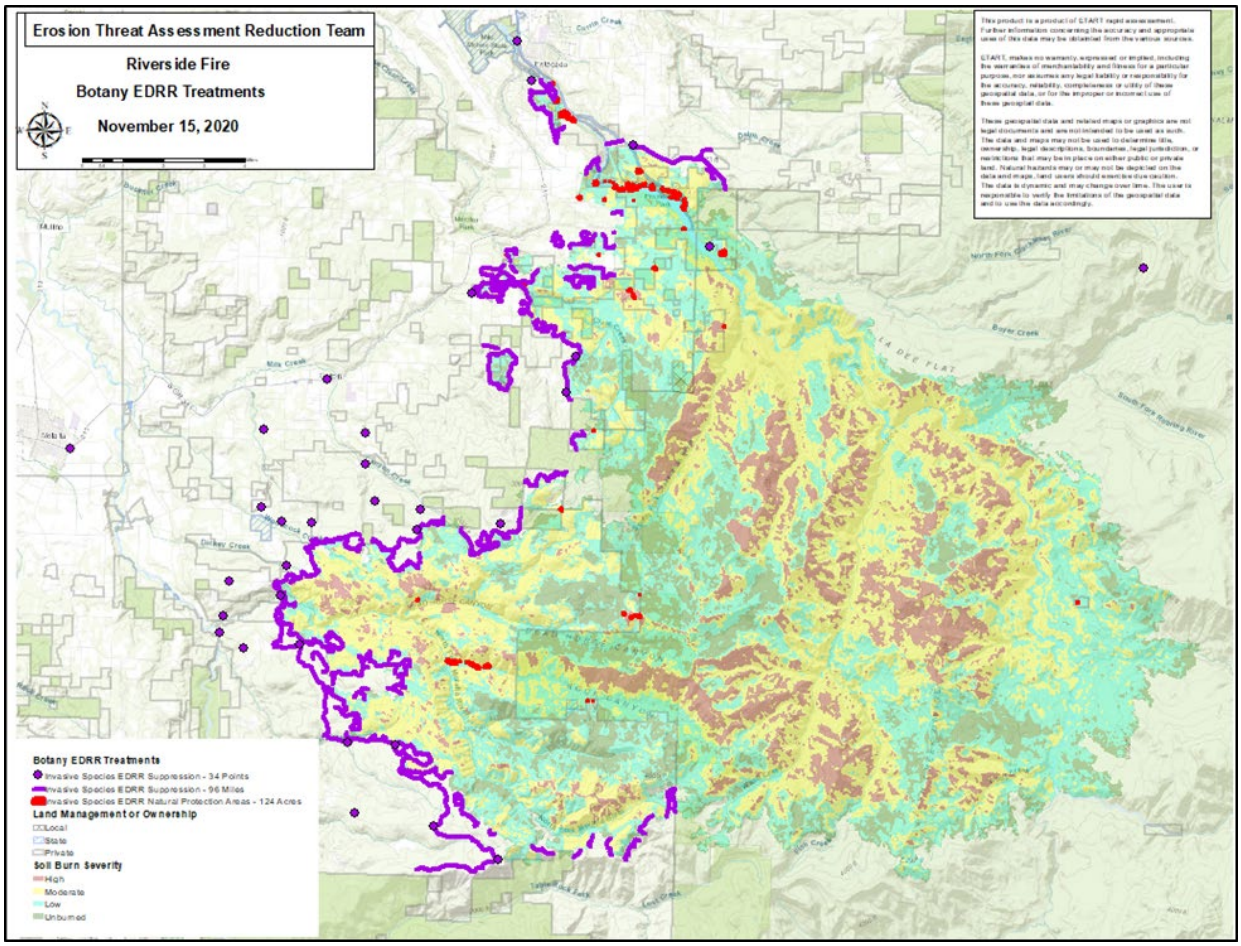

Figure 7. ETART EDRR Survey and Treatments – Riverside Fire

The cost estimates in Table 8 were prepared based on the recommended treatments. Estimates for noxious weed surveys, noxious weed treatments and T&E surveys were adapted from per acre rates for contracted restoration work in Clackamas County, 2020. Weed wash station estimates are based

on published rates from the Lemhi CWMA Weed Wash Station installation and operational costs. Community planning and outreach estimates are based on localized mailing and outreach events. Seeding prices are very diverse and depend greatly on sourcing of seed species and broadcast rate.

Critical Values and Recommended Treatments

Threat to Critical Value	Recommended Treatment
Establishment and expansion of viable populations of local and state noxious weeds classified as targets for Early Detection and Rapid Response (EDRR).	Implement EDRR weed surveys and if priority noxious weeds are identified, implement treatment using IPM-based principles with the desired goal of eradication. Emergent populations of local priority and containment weeds include orange hawkweed, gorse, slender false brome, Japanese knotweed, Bohemian knotweed, and garlic mustard. Ongoing monitoring is required.
Spread of noxious weeds during fire rehabilitation, reforestation, and salvage logging operations.	Implement sanitation and prevention protocols to prevent the spread of noxious weed with equipment and personnel. Use temporary or permanent equipment wash stations in the northern and southern ends of the fire to sanitize equipment during restoration, reforestation and salvage logging activities. A southern equipment wash station could also be used for prevention efforts in the northern portion of the Beachie Creek fire as well. Initiate noxious weed surveys along road systems and treat emergent populations of noxious weeds using IPM-based principles. Ongoing monitoring is required.
Establishment and expansion of fire-adapted noxious weeds on or near rural and residential properties	Initiate an outreach campaign to affected communities promoting Community Wildfire Preparedness Planning, and the importance of defensible space around homes and buildings. Survey for areas with high fuel loads and regeneration of fire-adapted weed species. Focus outreach into impacted areas in the communities of Colton, Dodge, Dickie Prairie, Elwood, Estacada, Highland, Molalla and Springwater, focusing on highly flammable noxious weeds such as Scotch broom, gorse, and Himalayan blackberry. Materials developed could be used for additional messaging to other residents in the wildland interface.
Spread of invasives due to contaminated gravel and rock products.	Prevent contamination of gravel and rock products by surveying and treating noxious weeds using IPM-based principles in and around active quarry operations. Require certified weed-free aggregate in all public contracting. Install a centrally located equipment wash station to sanitize vehicles and equipment used for the distribution of gravel and rock products. Any contaminated rock or gravel products should be quarantined and not redistributed. Ongoing monitoring is needed.

Threat to Critical Value	Recommended Treatment
Establishment and expansion of fire-adapted noxious weeds in fire suppression areas.	Target survey and treatments on dozer lines, hand lines, roadsides and suppression locations. Noxious weed surveys in these areas should include the identification of new or emergent weeds that may have been introduced during suppression activities. Emergent noxious weed populations should be treated using IPM-based principles. Reseeding heavily disturbed suppression areas and areas of high SBS using native or non-invasive seed as needed. Ongoing monitoring is required.
Establishment and expansion of fire-adapted noxious weeds on prioritized Oregon Department of Forestry Habitat Conservation Areas.	Implement noxious weed surveys in Habitat Conservation Areas with a focus on riparian habitat function. Treat new or emergent populations of identified noxious weeds using IPM-based principles. Ongoing monitoring required.
Establishment and expansion of fire-adapted noxious weeds near populations of rare, threatened, or endangered plants.	Implement targeted noxious weed survey in areas around sensitive species. Treatments of invasive weeds in sensitive areas should be implemented using IPM-based practices only when adverse impacts to protected species can be avoided. Focus should be on areas near suppression activities dozer lines, hand lines, and other suppression activity locations. Soil burn severity and vegetation mortality will increase the threat and dispersal of weed seed into sensitive areas. Ongoing monitoring is needed.
Invasive plant establishment and suppression of regenerating native plants in riparian areas.	Initiate surveys of riparian corridors. Treat new and emergent populations of noxious weeds using IPM-based practices. Past or current riparian restoration projects should be prioritized for survey and treatment. OWEB-funded projects occurring in the public and private land matrix of Upper Molalla River, Lower Clackamas River, and Middle Clackamas River should be surveyed upstream and downstream for potential dispersal and transport of noxious weeds. Replant areas with high mortality and poor natural regeneration.
Invasive plant establishment and suppression of regenerating native plants in late successional mixed conifer forest.	Limit access to old growth areas with high and moderate soil burn severity to minimize the potential for weed seed introduction into these areas. Survey these areas in subsequent years after vegetation has rebounded post-fire. Treat noxious weeds using IPM-based practices if new or emergent noxious weed infestations are identified.
Invasive plant establishment and suppression of regenerating native plants in wetlands.	Survey wetlands in areas with moderate to high SBS, and treat noxious weeds adapted for wetland sites using effective IPM-based practices. Replant areas with high mortality and poor natural regeneration.

Threat to Critical Value	Recommended Treatment
Invasive plant establishment and suppression of regenerating native plants in grassland, prairie, and meadow systems.	Initiate noxious weed surveys in conjunction with rare plant surveys, due to the rarity of this habitat compared to historical abundance. Treat new and emergent populations of noxious weeds using IPM-based principles. Avoid seeding unless native locally sourced seed can be secured. Ongoing monitoring is needed.
Invasive plant establishment and suppression of regenerating native plants in oak woodland habitats.	Initiate noxious weed surveys in conjunction with rare plant surveys, due to the rarity of this habitat compared to historical abundance. Treat new and emergent populations of noxious weeds using IPM-based principles. Avoid seeding unless native, locally sourced seed can be secured. Ongoing monitoring is needed.
Establishment and expansion of agronomic noxious weeds following fire-related disturbance.	Implement noxious weed surveys for important agronomic weeds. Treat new and emergent noxious weeds using IPM-based principles. Prevent the spread of fire-adapted weeds from suppression activities onto adjacent agricultural lands designated as" prime farmland", or "farmland of statewide importance". Reseed heavily disturbed areas if needed. Ongoing monitoring is needed.
Establishment and expansion of economically important noxious weeds in industrial timbers lands.	Implement sanitation and prevention protocols to prevent the spread of noxious weeds with equipment and personnel. Use temporary or permanent equipment wash stations in the northern and southern ends of the fire to sanitize equipment during restoration, reforestation and salvage logging activities. A southern equipment wash station could also be used for prevention efforts in the northern portion of the Beachie Creek fire. Initiate noxious weed surveys along road system and treat emergent populations of noxious weeds using IPM-based principles. Focus should be on eradicating fire-adapted weeds from suppression activities on or adjacent to timber operations that may adversely impact timber production through direct competition, or by altering the fire return intervals (i.e. false brome, gorse, scotch broom, blackberry, knapweeds). Ongoing monitoring is needed.

Table 8. Cost Estimates for Invasive Plant and Noxious Weed Treatments – Riverside Fire

Recommended Treatment	Unit	Number of Units	Estimated Unit Cost	Total
EDRR Surveys and Treatments – Natural Vegetation Protection Areas (includes follow-up treatments on 124 acres)	acre	248	$326	$80,848

Recommended Treatment	Unit	Number of Units	Estimated Unit Cost	Total
EDRR Survey and Treatments – Fire Suppression Operation Disturbances (includes follow-up treatments on 142 acres)	acre	284	$326	$92,584
Weed Wash Stations (purchase and operational expenses)	each	2	$150,000	$300,000
Community Wildfire Planning Outreach	lump sum	1	$25,000	$25,000
Threatened and Endangered Surveys	acres	248	$82	$20,336
Native Seed and Revegetation	acres	120	$1,500	$180,000
Total				**$698,768**

Best Management Practices (BMP) Recommendations

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

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

Recommended Monitoring

Noxious weed related concerns can take several years to manifest from an introduction event or seedbank. Emergent populations of new weeds can also take several years to control. Ongoing population monitoring of treatment areas is needed for 3-5 years. Follow-up monitoring in the same season is also needed to assess treatment efficacy and to prevent late season cohorts from seeding and recharging the seedbank.