Oregon Department of Transportation

Stage 1 Research Problem Statement

Number*: 25-13*

Proposed Title: Collection of Perishable Post-Fire Landslide Data through Continued Observation and Monitoring

1. Concisely describe the **transportation issue** (including problems, improvements, or untested solutions) that Oregon needs to research.

Landslides frequently impede transportation in Oregon, costing the state tens of millions of dollars annually through maintenance and repair, while diminishing system reliability due to closures. Landslides, in particular debris flows, are often more frequent following severe wildfire because of burned vegetation, altered catchment hydrology, hillslope erosion, and rainfall. Debris flows are a particularly hazardous type of landslide that can travel for miles, entrain boulders and trees, and move up to 40 mph with the density of concrete. Oregon has seen unprecedented wildfire activity in recent years owing to changes in forest management and climate. After 4-6 years, the legacy of wildfire disturbance has caused extensive landslide events in some locations, such as the Columbia River Gorge, resulting in highway closures and tragically, a fatality. At other wildfire sites that are more recent (i.e. the 2020 Labor Day Fires), there has been less pronounced landslide activity. It currently remains a mystery as to whether these differences in landslide activity owe to different climatic events (e.g. differences in intense rainfall), different topographic or geologic controls, or simply a more rapid recovery. In absence of continued monitoring and analysis of post-fire landscape response from efforts such as SPR853, we leave Oregon's traveling public and infrastructure at risk from post-fire landslide impacts. As the initial monitoring effort that has focused on Oregon's burned landscape is nearing its conclusion, it is readily apparent that continued monitoring and evaluation of post-fire controls on debris flows is essential to assess whether the legacy of wildfire as a driver of landslides and impacts to ODOT right-of-way are as prolonged as it appears to be.

2. Document how this **transportation issue** is important to Oregon and will meet the Oregon Research Advisory Committee Priorities

Every year, debris flows cause road closures, damage highway bridges and culverts, and in some tragic instances, result in human casualty. This precarious condition threatens ODOT's mission in many ways: debris flows are a significant risk to user safety; they create inefficiencies by delaying traffic and requiring ongoing maintenance work; and they are an economic burden on the state as the cost of traffic delays impacts the cost of goods and services that rely on the highway network, they affect lifelines and the mobility of goods and services between vulnerable communities. These challenges are likely to worsen with the alarming climatic changes we have seen in recent years, resulting in more frequent and severe wildfires. ODOT's Climate Change Adaptation plan has successfully continued to develop strategies to increase transportation resilience. It is evident that mitigating debris flow impacts stemming from longer, warmer summers and the intense wildfires they bring aligns with this important strategic effort.

There is currently a team of researchers working under SPR853 seeking to monitor and quantify potential impacts from post-fire landslides, which is entering its final year. The team has established six weather+soil monitoring stations in burn scars ranging from one to six years old, mapped post-fire landslides in numerous wildfire scars using aerial imagery and/or lidar change detection, and have been gathering soil and vegetation data from burn areas for the past years as a means of evaluating the timescales of wildfire legacy on landsliding. The team has developed a prototype warning system for debris flow channels that will be installed in January-February of 2024. The team has observed extensive landslide activity sourcing from the 2017 Eagle Creek wildfire perimeter; however, there has been distinctly less activity from the monitored wildfires that burned in 2020 and 2021. Consequently, it is still unclear as to (1) what the timescales of post-fire recovery are with respect to landslide rates, and (2) whether distinct differences in post-fire activity between sites owe to discrepancies in rainfall events, geology and/or recovery. It is of paramount importance to quantify the timescales of which post-fire landslide activity is heightened, and continued collection of strategic, perishable data is necessary to answer these key questions relating to landslide risk along ODOT right-of-way. By better constraining the timescales of recovery, ODOT would benefit as they could maintain safe driving conditions and better prioritize and plan mitigation efforts.

3. What **final product or information** needs to be produced to enable this research to be implemented?

Information collected for this project would expand and continue the efforts from SPR853, which is focused on establishing tools and data that inform the timescales of heightened post-fire landslide susceptibility. The project team has acquired extensive USFS permitting, which took substantial effort and time, to install monitoring systems in burn areas. This monitoring includes six weather+soil monitoring stations in three wildfire areas, spanning burn years from 2017-2022. These stations have been valuable in monitoring conditions associated with debris flow events (or lack thereof); however, they require maintenance and upkeep considering the harsh environment in which they are placed. Further, we are still monitoring to see if more debris flow events will occur, particularly in the areas that burned in 2020 and 2022. It will require continued observation to understand whether the most significant debris flow activity occurs 4-5 years after wildfire (as observed in the 2017 Eagle Creek Wildfire) or whether this activity is more a function of geology and climate. These continued observations will enable evaluation of how generalizable post-fire debris flow hazard assessments in western Oregon might be.

We expect to maintain and continue (1) our current monitoring systems that are simple-but-effective, continue (2) in situ site visits and soil/vegetation testing, and (3) continue and expand our remote monitoring with satellite imagery and aerial lidar collection/analysis Continued collection of this data is of value as it may inform approximate debris flow size and arrival time to ODOT right-of-way. This data will continue to inform empirical models that are being developed for predicting evolution of debris flow susceptibility. This framework will enable scenario-based evaluation of potential debris flow susceptibility in consideration of time since fire. Special attention will be placed on complementing these efforts with data collected from other ODOT investments, including prior research projects and proposed investments in post-fire landslide monitoring and mapping (SPR853), as previously described. The following tasks will continue from and be expanded from SPR853, including:

1. Review and compile existing data on debris flow occurrence in Oregon for a wide range of fires and climatic regimes. Identify rainfall intensity and/or magnitude parameters (e.g., rainfall quantity with time such as 24-hour rainfall, max hourly rainfall intensity) to best predict debris flow initiation and associated travel distances and volumes. Review empirical approaches used for the Southwestern US, runout models that could be leveraged for debris flow travel, and compile data on the location and morphology of past debris flows.
2. Maintain network of modular monitoring systems installed upstream of channels that cross ODOT right-of-way. Deploy sensor network in debris flow-prone terrain along critical burned corridors with ODOT guidance in Mosquito Creek. Continue to collect and analyze rainfall, soil moisture and shallow well data from wildfire locations allowed by permit from the USFS to compare differences between recently burned catchments (limited debris flow activity) and catchments burned six years ago (significant debris flow activity). Further curate and establish relationships between rainfall and hydrologic response as a control on observed debris flow activity.
3. Continue to remotely map landslides and debris flows from burned areas as a means of establishing empirical rates of post-fire landslides and debris flows as a means of training data-driven models that inform the evolution and recovery of burned landscapes. Use these mapped rates to compare differences

between recently burned catchments (limited debris flow activity) and catchments burned six years ago (significant debris flow activity).

4. Continue to collect vegetation and soil data from burned areas, potentially expanding data collection more recently burned sites (e.g. Camp Creek or Tyee Ridge fire perimeters). Continue to collect and curate root strength versus time since fire data, which demonstrates a notable dip in strength at the 3-4 year post-fire timeframe, consistent with extensive debris flow activity following the 2017 Eagle Creek wildfire.
5. Continue to develop a framework that will enable ODOT planners, geologists, engineers and emergency managers to quantify the evolution of post-fire debris flow susceptibility that is easy-to-use and computationally efficient for near-real time or scenario-based planning.

In short, this work would continue to support ongoing monitoring and collection of perishable data in some of the most prolific wildfire perimeters in Oregon history over a period where debris flow activity could be heightened in the scars of the infamous 2020 Labor Day Fires. Collection of this data will enable improved evaluation of post-fire landslide hazard and its potential impacts to ODOT right-of-way under the shadow of a changing climate. The investment is this research is not in vain if major debris flow events do not occur after continued monitoring and observation. In fact, this outcome will be equivalently important as observed major debris flow activity. Lack of debris flows would suggest that distinct differences in geology and recovery regimes dictate post-fire debris flow activity Such an observation would suggest that parts of Oregon may indeed follow the debris flow behavior of arid climates (e.g. southern California) and less so of steep, volcanic catchments, such as the Columbia River gorge, where some of the most impactful post-fire debris flow activity has been observed. These observations would help tune models that are used to evaluate post-fire debris flow hazards in different climatic settings (e.g. USGS post-fire debris flow model).

4. (Optional) Are there any individuals in Oregon who will be instrumental to the success of implementing any solution that is identified by this research? If so, please list them below.

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5. Other comments: N/A

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