FACTORS INFLUENCING WATERSHED RESILIENCE TO WILDFIRE
LARIMER COUNTY

COLORADO STATE UNIVERSITY EXTENSION

Nate Fraser

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PROJECT INTRODUCTION

Watersheds in fire-prone regions, such as Colorado, suffer from active and post-wildfire disasters impacting regional water resources, infrastructure, and ecology

- As higher severity wildfires become more common in the western United States, understanding attributes of watersheds that create resiliency to active and post-wildfire hazards is crucial to mitigating damage to water resources and environment.
- Burned watersheds lack stable vegetation and contain large coverage of fine material from combusted organic matter resulting in reduced ground cover, infiltration, and erosion thresholds.[1,2]
- These altered attributes of burned watersheds cause increased flow, sediment, and nutrient fluxes heightening risk of debris flows and flooding.[3]
- Resiliency to these fluxes vary at a reach-scale within watersheds, attributed to characteristics such as valley geometry, spatial heterogeneity of the river corridor, vegetation, and 3D connectivity within the stream corridor.[4]
- The Cameron Peak Fire of 2020 burned a variety of watersheds along the Cache la Poudre river. Over the following years, these watersheds experienced debris flows of differing intensities dependent on the characteristics influencing response to disturbance.
- In July of 2021, a large storm passed over the Cameron Peak burn area causing a devastating debris flow at Black Hollow resulting in water quality issues along the Poudre, habitat destruction, damage to infrastructure, and tragically, the loss of 4 lives.[5]

Figure 1: Remains of Black Hollow debris flow

INTERNSHIP GOALS

Figure 2: Crutching around field site along Cache la Poudre

Project Goals

- Select, map, and characterize river basins that experienced debris flow as a result of the Cameron Peak Fire
- Define reaches in watersheds and quantify components contributing to debris flow attenuation
- Determine the scale of erosional and depositional zones along river corridor relative to post-debris flow log jams

Personal Goals

- Obtain practical field work experience and build up my skills in data analysis and ArcGIS.
- Build connections with other researchers and mentors in the fluvial geomorphology department
- Learn more about the research and application of natural hazard mitigation.

METHODS

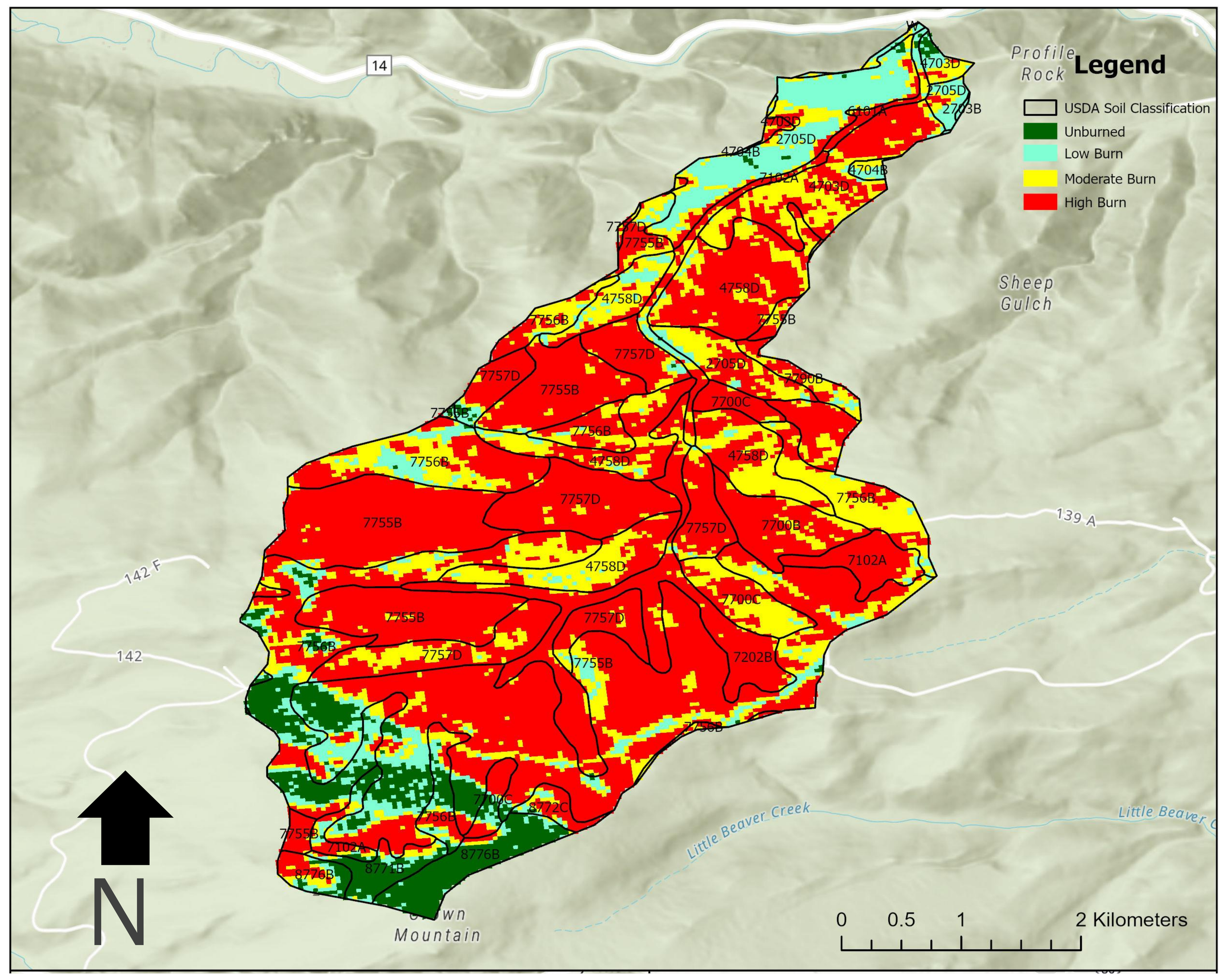

Figure 3: Burn severity and soil classification of Black Hollow

Defining Basins and Reaches

Basins encompassing sites of recorded or evidence of debris flow since 2020 were selected. Basins were delineated and site maps of each basin were created with ArcGIS detailing the basin topography, soil and bedrock composition, erosion factors, and burn severity. Mainstem channels were broken up into reaches which were defined as longitudinally continuous portions of stream corridor with consistent formation. Reaches were waypointed and surveyed for topography, bedform, channel formation and other features.

Mapping Erosion/Deposition

Digital Elevation Models (DEMs) of pre and post-debris flows were compiled and modified to fit the basin area by utilizing OpenTopography and ArcGIS. Mainstem channel boundaries and inlets were then defined, and a DEM of difference was created within the boundaries. This model indicated regions of erosion and deposition caused primarily by debris flow by the change in elevation from pre-debris flow LiDAR scan and more recent ones. Arial imagery of post-debris flow in Black Hollow was then surveyed and significant log jams within the mainstem floodplain were mapped to analyze how they affect the formation of erosional and depositional zones along the river.

Log Jam Significance

From the erosional/depositional zones mapped out in Black Hollow, log jams were categorized to exist longitudinally within erosional or depositional zones. Log jam counts were then compared to the spatial extent of these zones. In order to determine whether these result were significant F-tests and T-tests were performed on Excel to see if log jams do control erosional/depositional patterns.

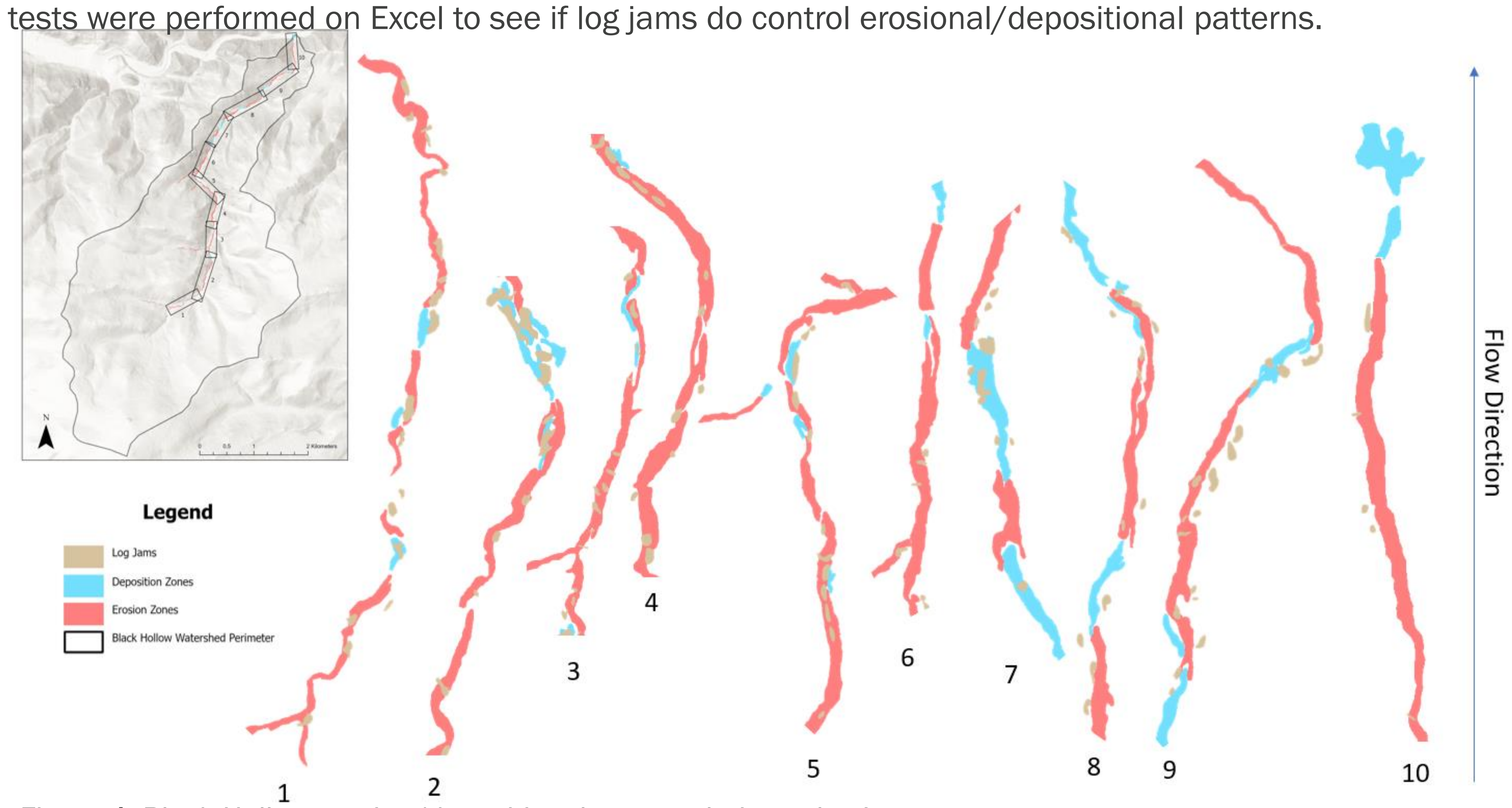

Figure 4: Black Hollow erosion/depositional zones relative to log jams

DISCUSSION

During debris flows, large amounts of sediment are displaced from these violent flows. Wood matter is some of the largest and oddly shaped of these materials carried by the flow causing them to build up together and create log jams. These jams take up space in river channel and floodplain causing the diversion of river flow and altering the dispersion of sediment carried by these flows. However, their relative placement along these channels and flooplains has no significant correlation with large scale sediment build up or loss.

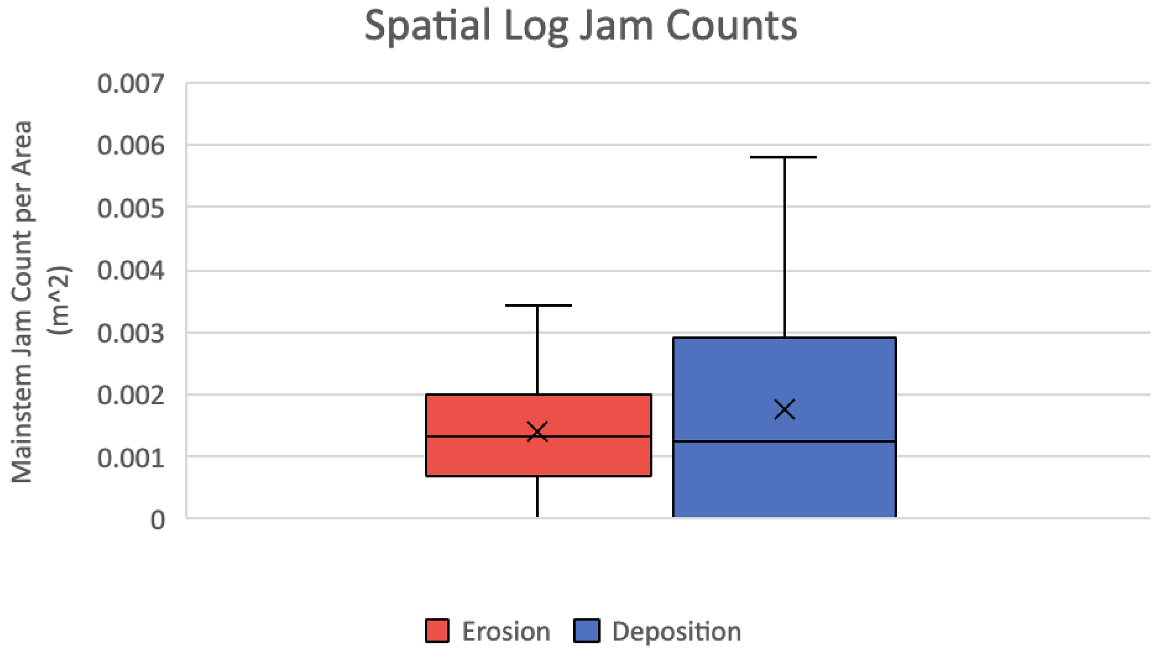

Figure 5: Box plot of log jam counts divided by associated erosional/depositional zone. Two sample unequal variance t-test outputted a t stat of -.84 and P value of .41

The results of the t-test indicate that the association between log jam counts and erosion/deposition zone were not statistically significant meaning that there are other factors contributing to the pattern of erosion and deposition observed at Black Hollow. However, this outcome aligns with other current work on the Black Hollow debris flow and raises other questions as to what attributes of the river system control the placement and removal of sediment in typical extreme flow states.

NEXT STEPS

- Carry out these methods on other basins that experienced serious debris flow following the Cameron Peak Fire and compare results
- Consider and analyze other factors that could contribute to patterns of erosion and deposition
- Look at log jams compared to tributary angles and longitudinal trends

References

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