

UAV (DRONE) REMOTE SENSING OF CAMERON PEAK WILDFIRE WATERSHED IMPACTS, LARIMER COUNTY, CO

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INTRODUCTION: CAMERON PEAK FIRE

In 2020, the Cameron Peak Fire (CPF) burned over 208,000 acres in the northern Colorado Front Range. Located immediately west of Fort Collins, CO (Figure 2), the fire ignited in mid-August and was 100% contained on December 2, 2020, 112 days after it was first noticed¹. Though the cause of the fire is yet to be concluded, a combination of high temperatures, low humidity, windy conditions, and high fuel loads contributed to the CPF's rapid growth². Steep, hazardous terrain limited the ability of fire crews to directly fight the fire. The combination of these factors contributed to the CPF becoming the largest wildfire in Colorado history. The CPF's rapid growth led to significant damage to structures and numerous evacuation orders, including at the CSU Mountain Campus, where the author (Suhr) was working in August 2020. A total of 469 structures were destroyed or damaged¹. Damages to roads, trails, campgrounds, and water resource infrastructure were sustained from the CPF's growth and during fire fighting efforts¹. In addition to the immediate effects of the fire, significant long-term impacts on the landscape and watersheds burned by the CPF include *i.*) soil erosion (e.g., Figure 1.B), *ii.*) landslides and debris flows (e.g., Figure 1.A), *iii.*) increased risk of flash flooding², and *iv.*) impacts on the quantity and quality of water in key watersheds for municipal water supplies³.

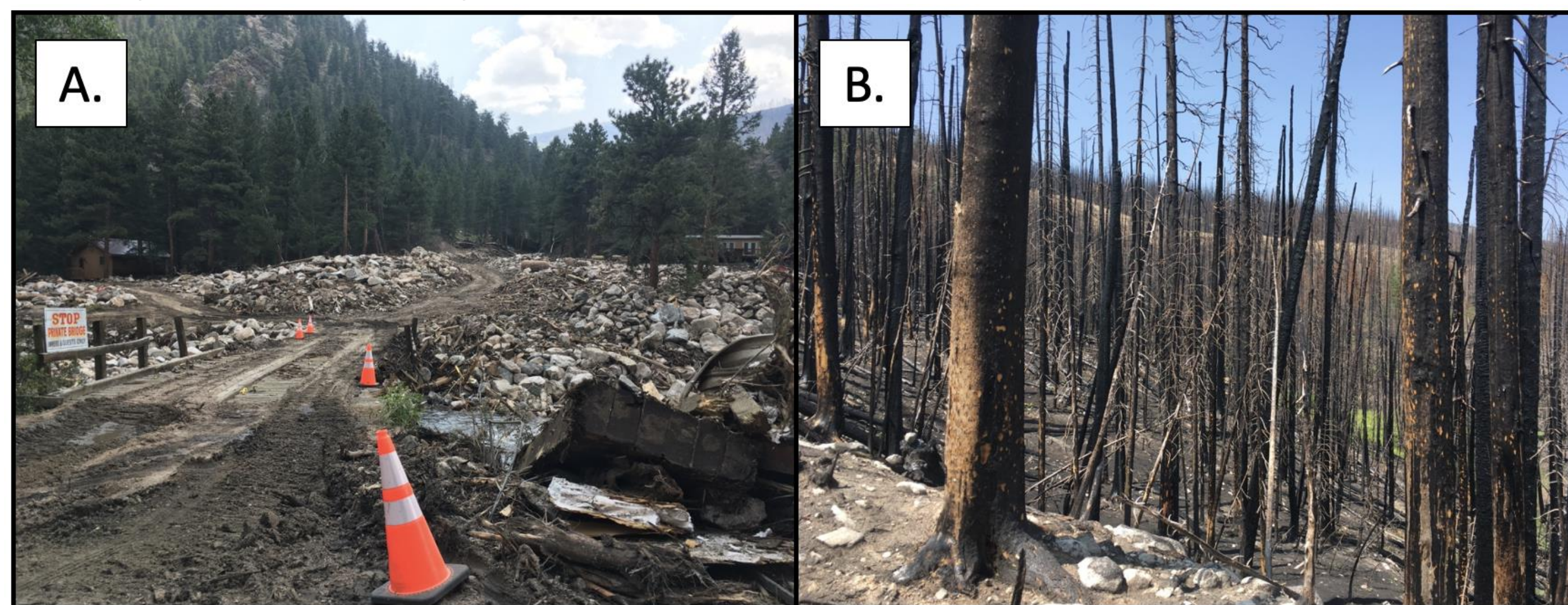


Figure 1: A. Photo of damage caused by the Black Hollow debris flow event – large boulders, wood, and pieces of structures deposited in Poudre Canyon. B. Burned hillslope above Chambers Lake – lack of vegetation regrowth and evidence of soil erosion is clear in the foreground.

INTERNSHIP OBJECTIVES

To support research studying the post-fire landscape and watershed impacts of the CPF, I pursued the following goals:

- 1.) Collect UAV imagery of small watersheds, other monitoring sites
- 2.) Produce high-resolution orthorectified images & digital elevation models (DEM) of study sites
- 3.) Develop data collection & processing workflows for the DJI Phantom 4-RTK UAV system (P4RTK) acquired for this project

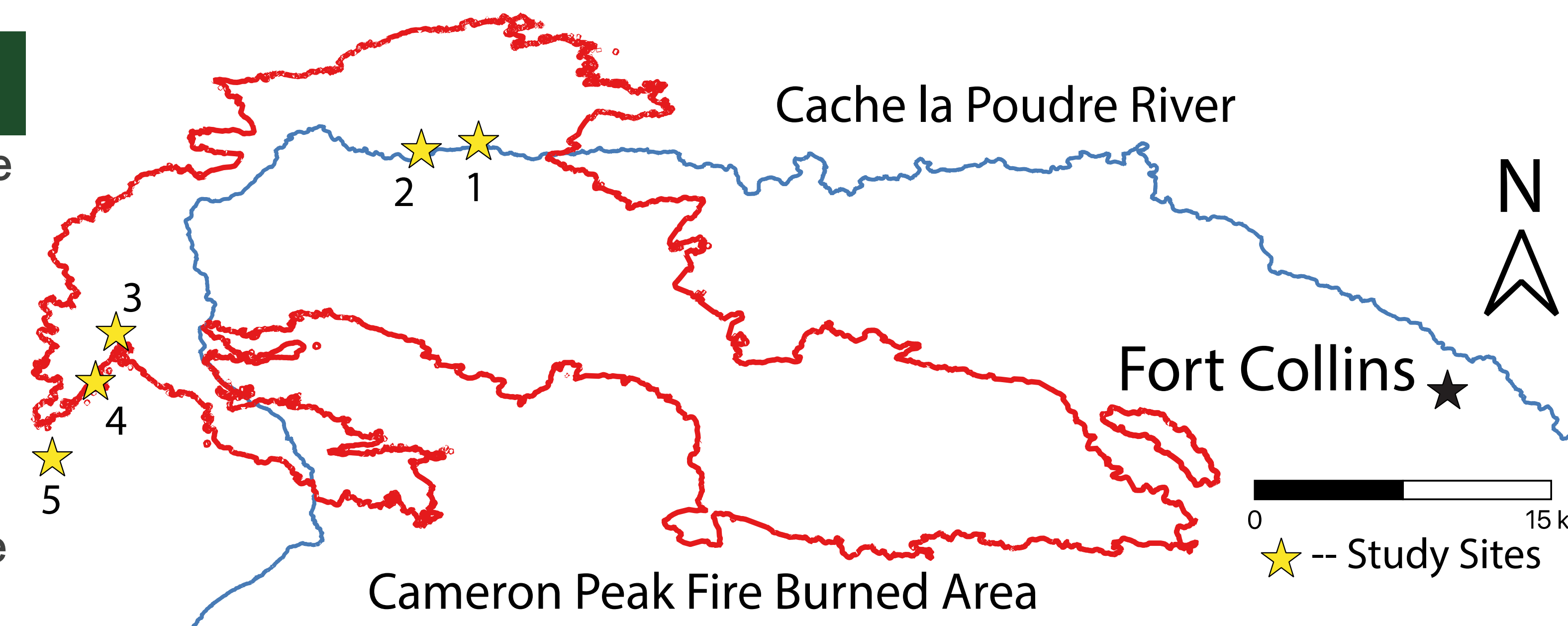


Figure 2: Location map of drone surveys completed in summer 2021. Sites 1-3 examined small tributaries of the Cache la Poudre River, sites 4 and 5 supported research about the CPF's impact on the snowpack.

DATA ACQUISITION

From May-August 2021 I surveyed five study locations with project co-intern Mary Williams using the P4RTK. Sites 1-3 (Figure 2) focused on Earth surface processes occurring in response to the CPF. Landscape changes that we hoped to capture at these sites include hillslope and channel erosion and sedimentation, and vegetation regrowth. Mary and I completed a repeat survey to document change occurring over the summer at site 3 and completed a partial repeat survey at site 1. Sites 4 and 5 supplemented other work focusing on the CPF's impacts on the snowpack. These two sites contrast snowmelt patterns inside (site 4) and outside (site 5) of the burned area. Images collected from each survey were developed into orthorectified images (e.g., Figure 3.A) and digital elevation models (e.g., 3.B) using structure-from-motion (SfM) software.

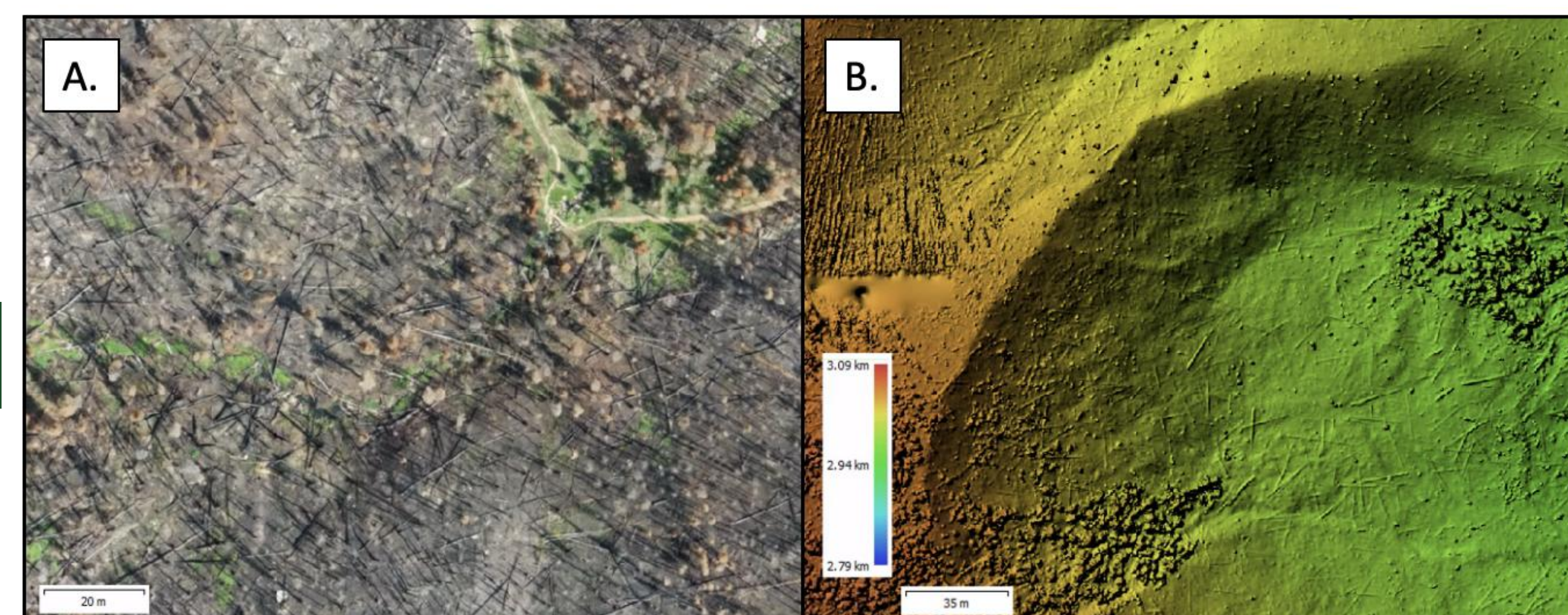


Figure 3: A. Ortho image of a small stream crossing the Blue Lake trail (site 3). Imagery shows patterns of vegetation regrowth & wood loading in streams following the CPF. B. DEM and hillshade at site 3. This image shows a landslide scarp at the head of a drainage. Downed logs are clear in the center of the image.

WORKFLOW DEVELOPMENT

The P4RTK system that I used to collect imagery was newly acquired for high-resolution drone-based surveying for this and successive projects. Therefore, a key effort of this internship was developing and testing workflows for the operation of the system, and for SfM processing using images collected using the P4RTK system. Workflows and general flight considerations using this system are available through the CSU Drone Center. Aspects considered by these workflows include developing terrain following flight plans suited for surveying in high-relief areas, and preflight considerations for operating the drone in mountainous settings. To develop accurate, reproducible surveys, workflows outline key SfM processing steps and make recommendations about the use of ground control points when developing SfM products with this system.

FUTURE WORK

Data that I collected during this internship captures the initial condition of a landscape responding to a wildfire. Data products can be leveraged by researchers and land managers via repeat surveys of these sites. Differencing repeat DEMs of these sites will allow researchers to study erosion and sedimentation occurring following the CPF. DEM differencing efforts can help constrain sediment budgets, predict reservoir sedimentation, and understand how small stream channels change following wildfires.

EDUCATIONAL & PROFESSIONAL DEVELOPMENT

This internship provided an unparalleled opportunity to gain experience collecting data to assess post-fire landscape and watershed impacts. I learned to collect imagery using drones, obtained my FAA sUAS pilot license, and improved my skills using GIS & SfM software. Exposure to research questions about post-fire environmental response complemented my earth science education and underscored the management applications of this kind of research. I hope to continue studying the effects of wildfires on streams after I graduate.

REFERENCES

- ¹ Cameron Peak Fire Incident Overview – USFS: <https://inciweb.nwcg.gov/incident/6964/>
- ² Cameron Peak Fire BAER Executive Summary – USFS: <https://inciweb.nwcg.gov/incident/article/7210/58918/>
- ³ Post-Wildfire Watershed Restoration and Recovery – City of Fort Collins Utilities: <https://www.fcgov.com/utilities/2020-wildfires>