Quantifying Oregon State Forest Landslides Using UAV Structure from Motion

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Abstract

This poster presents the findings of repeat topographic surveys conducted on two landslides in the Tillamook State Forest of northwest Oregon.

Both landslides occurred on steep slopes with recent histories of industrial forestry. This project was conducted in partnership with the Native Fish Society, 501(c)3, to measure the areas and volumes of erosion and deposition associated with each landslide.

Baseline topographic data, captured prior to the landslides, was from publicly available lidar data from state-sponsored manned aircraft surveys. Data from after the landslides was collected using Unmanned Aerial Vehicles (UAVs) and processed using Structure from Motion (SfM) photogrammetry techniques to acquire topographic data.

The UAV data acquisition was cost and time effective and resulted in high resolution point-cloud data for volume analysis. The differences between the lidar and UAV datasets was used to identify areas of erosion, deposition, and highlight impacts to the West Fork North Fork Wilson River channel.

Introduction

Repeat Topo Surveys Prior Art

- Morphologic changes in rivers, landslides, etc (Laporte-Fuaret, 2019)
- For landslides using SfM (Lucieer, 2014, Gupta, 2017)
- UAV SfM data in reliable comparison to prior aerial lidar (Eker, 2017, Hamshaw, 2015)
- UAV SfM as time and cost-effective tool for landslide monitoring (Lindner, 2015, Gupta, 2017).

Figure 3: Wilson River landslide imagery from Google Earth Pro shows active roadbuilding in 2012 and subsequent landslide in 2016.

Study Site

- Tillamook State Forest near Lee's Camp, OR
- Two landslides in the Wilson River watershed.
- Roadbuilding and clear-cutting impacts on both.

Figure 2: Cedar Creek landslide satellite imagery time series. Source, Google Earth Pro.

Methods

UAV Surveys

- ~200 images per landslide with 3000x4000 pixel resolution
- Flown at 354' Above Ground Level (AGL) with Terrain Following (Figure 5)
- Final Ground Sampling Distance (GSD) of 1.2 inches/pixel
- 88% front and 88% side overlap

Post-Processing

- Stitching, orthorectification and geolocation to create GeoTIFFs
- Structure from Motion (SfM) to generate topographic data in DEM and LAS point-cloud

Figure 4: Quad-copter UAV used for post-landslide surveys.

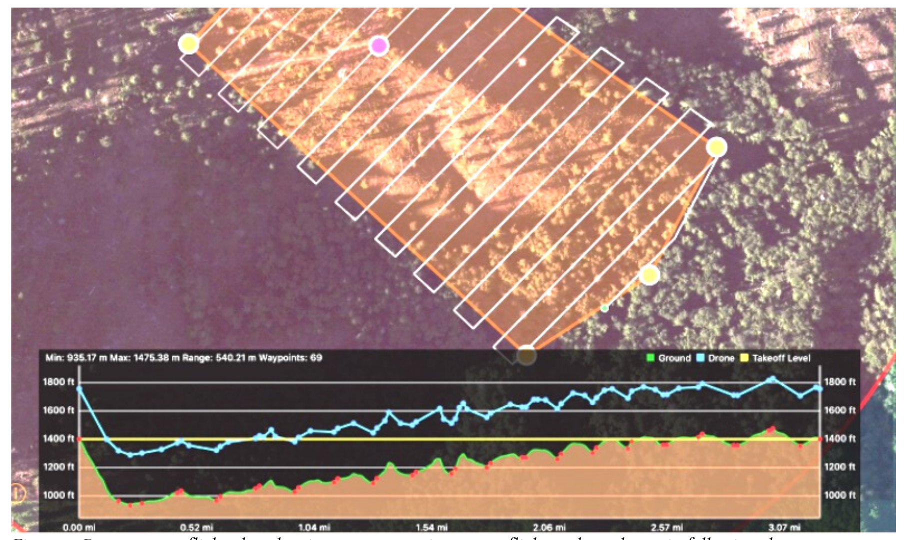

Figure 5: Drone survey flight plan showing survey area in orange, flight path, and terrain following chart.

Analysis

UAV Point Cloud Prep

- Cloth Simulaiton Filter (CSF) algorithm for tree vs. ground classification (Figure 9).
- Fine registration to reference lidar point cloud using Iterative Point Cloud (ICP) alignment (Figure 10).

Comparison to Reference

- Pre-landslide reference point-cloud from Oregon Department of Geology and Mineral Sciences (DOGAMI).
- Cut/Fill difference analysis to measure erosion and deposition (Table 1, and Figures 13 & 14).

Figure 9: Above, Cedar Creek full point cloud. Below, ground-only point cloud after CSF algorithm.

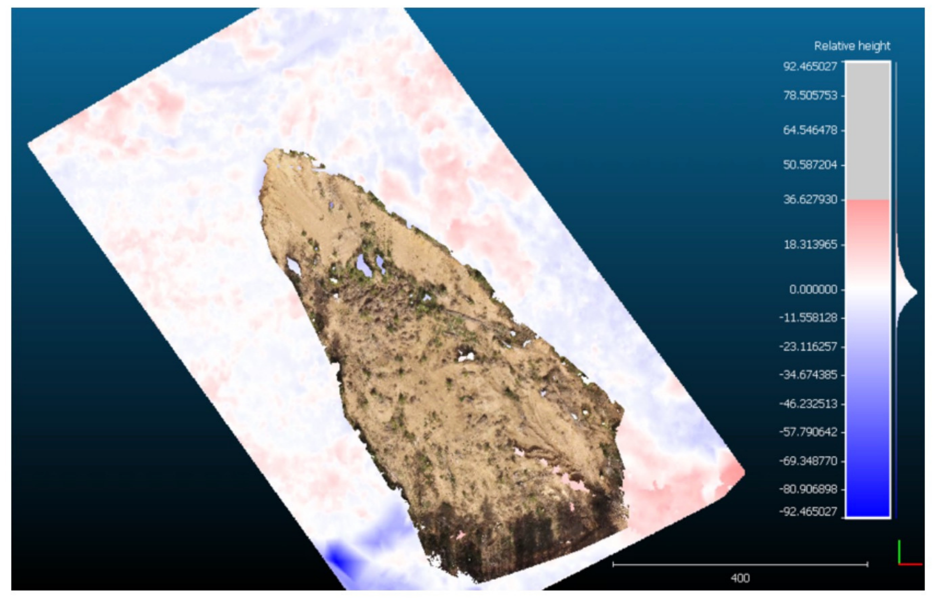

Figure 10: Cedar Creek proximal error visualization with histogram.

Results

Survey	Reference Data	Test Data	Change			
			Positive Change (deposition) (ft^3)	Negative Change (erosion) (ft^3)	Net Change (ft^3)	Net Change (yd^3)
Cedar Creek	2009 LIDAR	2019 UAV	1,217,888	2,085,751	-867,863	**-32,143**
Wilson Upper	2011 LIDAR	2020 UAV	104,392	342,949	-238,557	**-8,835**
Wilson Lower	2011 LIDAR	2020 UAV	485,308	340,512	+144,796	**+5,363**

Table 1: Compilation of volume measurements comparing UAV point clouds to reference LIDAR point clouds

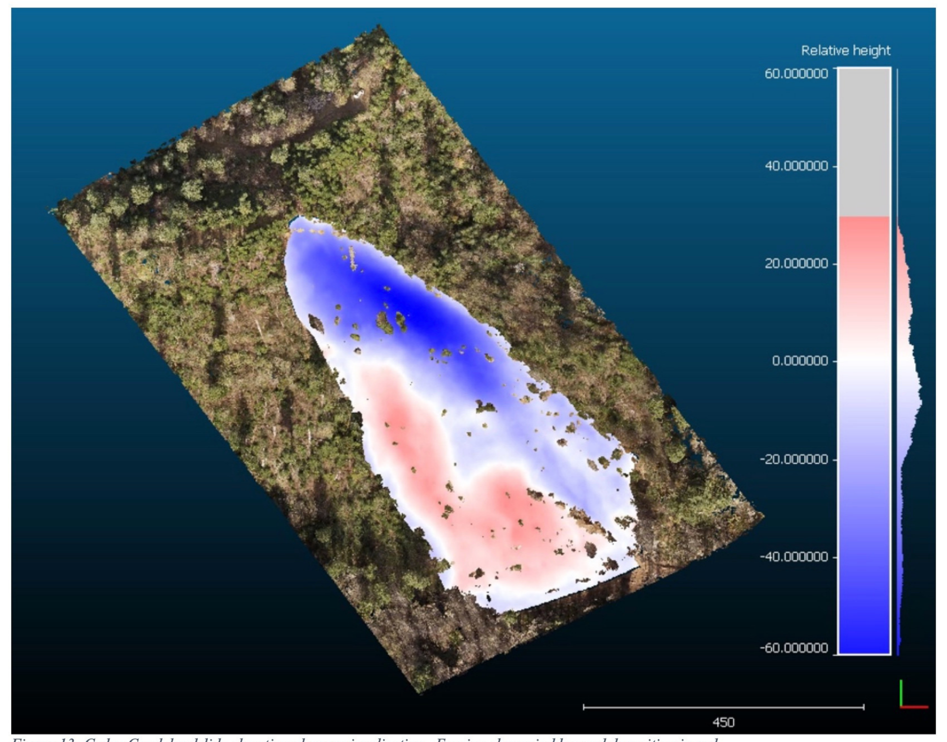

Figure 13: Cedar Creek landslide elevation change visualization. Erosion shown in blue and deposition in red.

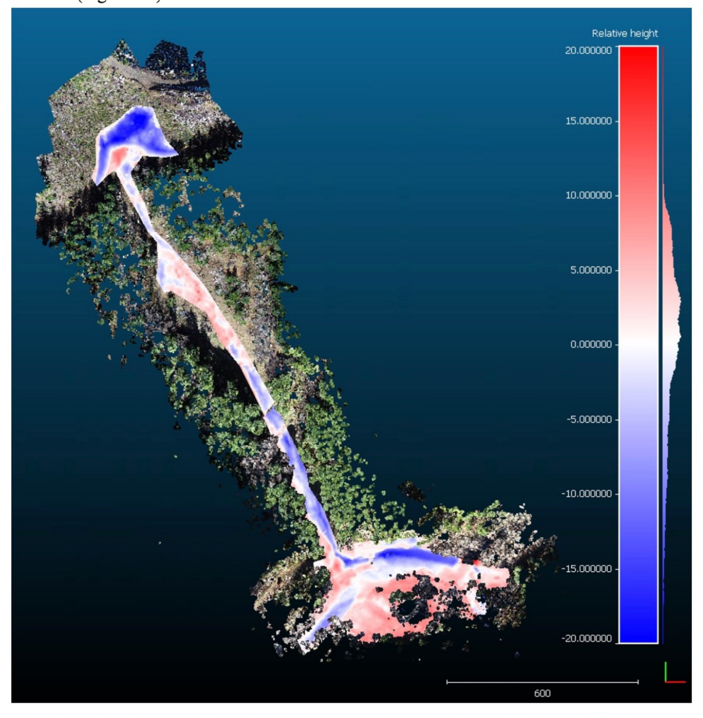

Figure 14: Wilson River landslide elevation change visualization. Erosion in blue and deposition in red.

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