Using GIS, Lidar, and Drone Imagery to Visually Represent Landslide Cutback at Deer Run Heights in Jeffersonville, VT

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Research Motivation

The most recent major landslide event at Deer Run Heights (DRH) located in Jeffersonville, VT occurred in 1999 (VGS, 2018; Figure 1). It left one home overhanging the ridgeline and threatened other residences with potential damage, including an elementary school and homes at the bottom of the slope (VGS, 2018). The geological factors that caused this event included poorly consolidated rock and soil materials, high levels of water in the soil, and erosion due to the river beside this site (VGS, 2018). Monitoring of this site includes using time domain reflectometry to identify fluctuations of strain with depth, soil moisture logging, depth to the water table, and cutback measurements along the ridge. Cutback measurements, which are the focus of this research, were collected in Aug 2006, Oct 2006, Apr 2007, Jun 2013, Aug 2016, and Sep 2018. The ridgeline of the landslide gulley complexes was measured using nineteen GPS-identified locations that are marked by stakes to help capture the rate of erosion at active areas by the distance from the stakes to the ridgeline.

Figure 1. Photograph of the landslide site at DRH following the 1999 event (VGS 2018).

Methods

The stakes were originally placed in August 2006, and cutback measurements were taken at every location since that time by measuring the distance from the stake to the ridgeline. A central bearing, and distance in meters, were collected. The distance at a bearing of ±30 degrees. GPS coordinates were taken at every stake location in order to relocate the stake in the future and to create GIS points. Stakes 2, 6, and 16 had updates over the years of data collection relating to tags or stakes. Stake 2 was distinguished in 2016 with 2 north (2N) and 2 west (2W) due to the shape of the eroding ridgeline. Stake 16 was lost between the 2016 and 2018 years, and a new stake was placed. The stakes can be broken into three categories representing the areas of movement. The northern region (red) includes stakes 2W and 2N, 3, 4, and 5. The central region (yellow) includes stakes 6, 7, 8, and 9. The southern region (blue) includes stakes 13, 14, 15, 16B, 17, 18, and 19 (Figures 2 and 3).

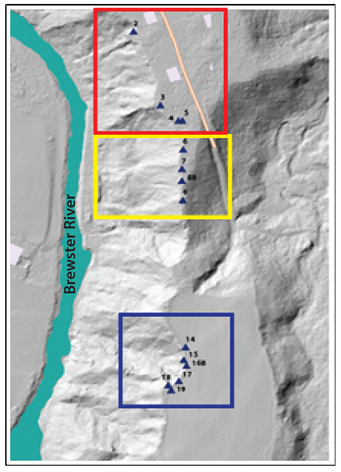

Figure 2. Stake location at DRH.

The research objective is to visually demonstrate cutback at the DRH landslide site through maps and 3D models.

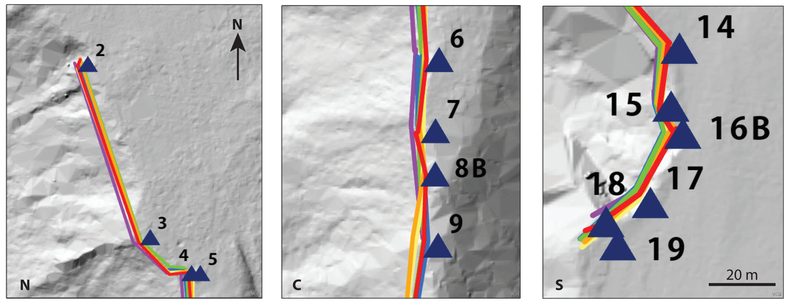

Figure 3. Cutback over the data collection years in the northern (N), central (C), and southern (S) regions. Color scheme defined in Figure 4.

Discussion

The northern region had an average change of 1.34 m, the central region had an average difference of 0.23 m, and the southern region had an average change of 0.81 m. On average, this site had a change of 1.48 m, which equates to approximately 0.12 m per year over the 12 years observed. The greatest changes, based on stake location, of the ridgeline over the study area occurred at 8B, 16B and 18. Stake 8B showed a change of 3.43 m. Despite this, the other stakes in the central region were no as extreme comparatively, stake 6 had a change of 0.91 m, stake 7 had a change of 0.96 m, and stake 9 had a change of 0.61 m. The southern region including the stakes 16B and 18 is quite active. In this area the smallest changes in the ridgeline this area was around stakes 13 and 14 (Figure 4).

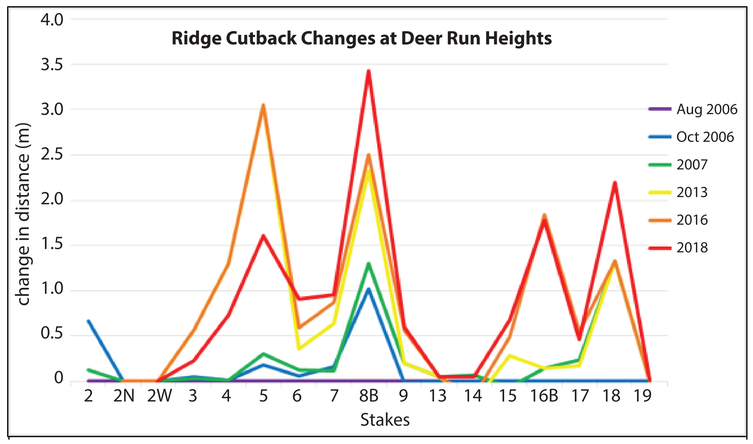

Figure 4. Change in ridgeline position at each stake for every collection year.

In addition to the collected measurements, assessments of stake locations susceptibility to material loss were speculated. Stakes 2, 3, 4, 5, 6, 7, 11, 14, 15, 16B, and 17 all had notable overhang throughout the collection years or demonstrated an active area, accounting for almost all of the stakes. The most significant assessments of loss of material visually seen were made at stakes 6, 7, and 14. The ridgeline at stake 6 was falling and could easily break apart with minimal weight. Stake 7 had overhang and began to slough off at +30 degrees from the central bearing. Stake 14 had approximately 20 cm of overhang.

Current Status and Future Work

Future drone flights of the landslide site should focus on the stake locations themselves, rather than capturing the grand picture (Figures 5 and 6). This will allow for use in QT Modeler, provide better location information, and allow for the calculation of volume loss of material at the landslide site. Additionally, there is also a possiblity for drone mapping the central region and building a 3D model, yet it is difficult given the amount of vegetation in this area.The GIS maps and associated video (Kolbenson 2018) demonstrate the change overtime. The 3D model offers multiple formats and focus areas of the landslide site to explore and describe the current state. In future years, this model can be compared to future measurements and updated 3D models in order to determine cutback along the ridgeline. Similarly, the GIS maps can be used to compare future measurements and new data points can be added to the software. The potential for damage on the local community reiterates the importance of continued surveillance of this area.

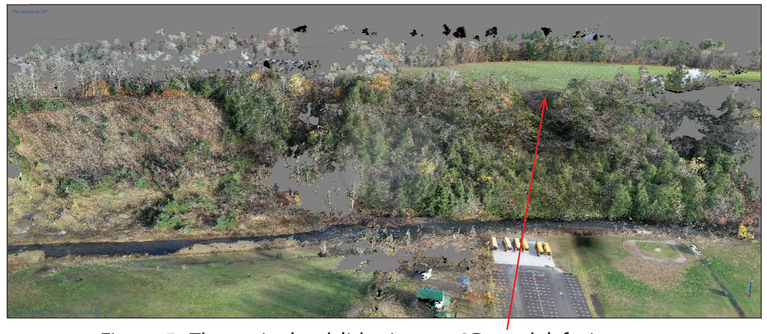

Figure 5. The entire landslide site as a 3D model; facing east.

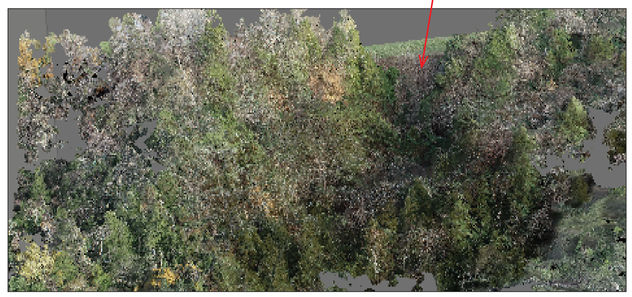

Figure 6 . A 3D model of the active southern region of DRH, near stake 16B, located above the parking lot of Cambridge Elementary School.

Acknowledgments

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Kolbenson's website: http://kanat.jsc.vsc.edu/student/kolbenson/drone.html