Establishing Methodology for LiDAR-Based Trail Monitoring

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Introduction

Across the globe, natural areas are suffering from trail erosion. Whether it be from natural weathering or from anthropogenic influence, trails are falling apart. Many studies have been conducted regarding various management and monitoring techniques, but these studies do not agree on any one method being ideal (Jewell & Hammitt 1999). New technology is constantly becoming accessible, and the development of ground-based LiDAR scanners in recent years has led to it being used in a variety of applications, from forensics to surveying. One study utilized airborne LiDAR in trail monitoring techniques but did not use ground-based LiDAR (Eagleston & Marion 2020). Our pilot project seeks to introduce the methodology of ground-based LiDAR scanning on mapping and modeling a trail and discusses future potential for using the methodology in planning and monitoring.

Methods

For our study area, we chose Maywoods, a 1,700-acre EKU Natural Area in the Knobs Region of Kentucky. There is a mountain bike trail under construction at this site, providing a prime location for us to set up a base map and monitor for future changes once the trail starts to see some use.

<u>Scanning the Trail:</u> To perform our LiDAR scans, we used a Trimble SX10 total station paired with a Trimble R10 360 Prism for our target, as well as a Trimble T10 tablet equipped with Trimble Access and Business Center. The T10 Tablet served as our remote user interface. Prior to scanning, the trail had to be cleared of any vegetation or obstacles. Once we were ready to scan, the total station was set up and leveled on a Seco tripod at designated control points. At each of these, the instrument height was taken and entered to complete station

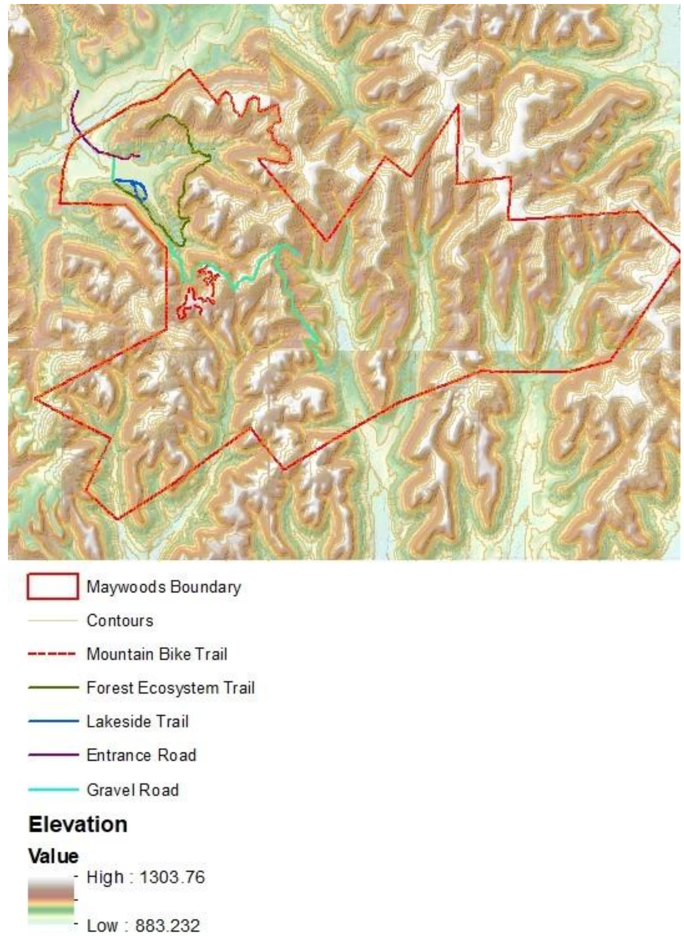

Figure 1: Base map of Maywoods (values in feet)

setup in Access. At each control point, we measured a backsight, typically where the instrument was previously set up at, and a forward control point where we planned to move the station to next. This kept the instrument calibrated in our grid system for proper alignment of scans and points. This had to be done due to a lack of a GNSS rover to georeference our data in the field. Control points were measured using the R10 360 prism, which we would place in the desired spot and target using the total station and the Measure option in Access. Once we had our control points, we would draw a polygon of the area we wanted the station to scan and allow it to complete. Each scan took around 3-5 minutes and took an average of around 400,000 points. After the completion of our field days, we had 24 instrument setup or control points, 85 individual scans, and 45,000,000 scan points. Some scans and points were trimmed due to irrelevance to the trail or due to improper calibration of the instrument.

Data Handling and Analysis: Once we completed our scanning, our data was in the form of a .job file on Access. We exported our file into Trimble Business Center, which allowed for viewing and error correction of raw LiDAR data. This software showed our full map of control points and scans within the grid system. Using Business Center, we exported our data in the form of a .las file, which we could then use in ArcGIS. This file was manually added to a .LAS database, or .LASD, in ArcCatalog, which then computed statistics for all 45,000,000 scan points. This data was then fully usable by ArcMap and other ArcGIS applications. I imported the .LASD into ArcMap first as a multipoint and then as a raster. The multipoint did not have much functional use, but the raster showed our trail in detail. It was georeferenced using a tool on ArcMap and placed our base map overlaying a shape file for the mountain bike trail. Once we had the georeferenced raster, I also imported it into ArcScene and viewed the 3D model of the trail, including its slope and curvature.

Results

Once the georeferenced raster was completed and placed into the proper location, a base map (shown in figure 1) was created, as well as 3D models of the trail scans and an elevation profile for the area scanned.

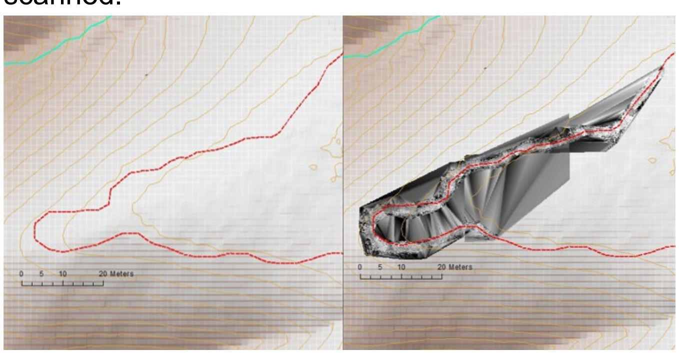

Figure 2: Trail shapefile without raster (left) and with raster (right)

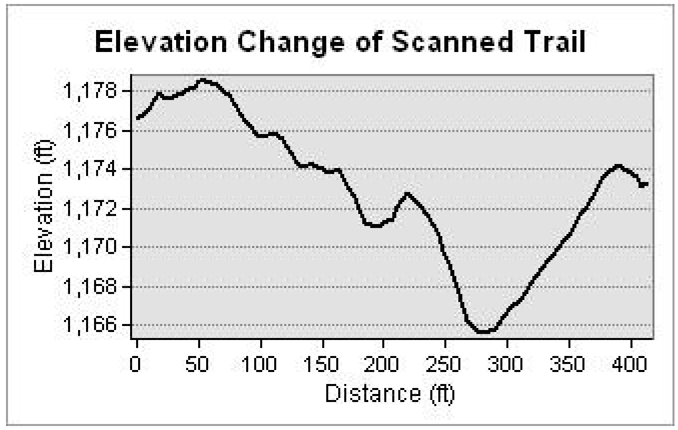

Figure 3: Elevation profile of scanned length of trail

Conclusions

Not enough time was provided to complete a time series, which would have given us comparable data to measure erosion and trail alteration. The methodology, however, has been tested and with fine tuning is ready for future application. Using this methodology, researchers could monitor for minute changes to trail topography and width, as well as plan for future changes to the trail by examining 3D models. As this methodology is still new and relatively expensive, its application is limited to those with the ability to procure the necessary equipment and software licensing. It could, however, provide a very useful tool in the field of conservation research to determine whether natural processes or human influence is causing most of the trail damage, and could be used to address what can be done to build trails sustainably.

References

Eagleston, H. and Marion, J. (2020). Application of airborne LiDAR and GIS in modeling trail erosion along the Appalachian Trail in New Hampshire, USA.

Jewell, Mark C., Hammitt, W. (1999). Assessing Soil Erosion on Trails: A Comparison of Techniques.

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