A Methodology For Developing Photorealistic Representations of Oak Woodlands Using LiDAR and Multispectral Imagery

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Introduction

Spanning 722 acres of the southern foothills of the Sierra Nevada Mountain Range, River Ridge Ranch (RRR) serves as a conservation hotspot, ecological reserve, and a flourishing blue oak woodland. Sustainable management of RRR plays a pivotal role in supporting important ecosystem services like groundwater recharge, carbon sequestration, and soil erosion reduction. Current remote sensing methods have significantly changed earth science research, especially within terrestrial ecosystems. However, the implementation of LiDAR for modeling terrestrial ecosystems has expanded the current bounds of remote sensing research. Our project was designed to provided a methodology for developing and visualizing photorealistic representations of Oak Woodlands within RRR using LiDAR and multispectral imagery.

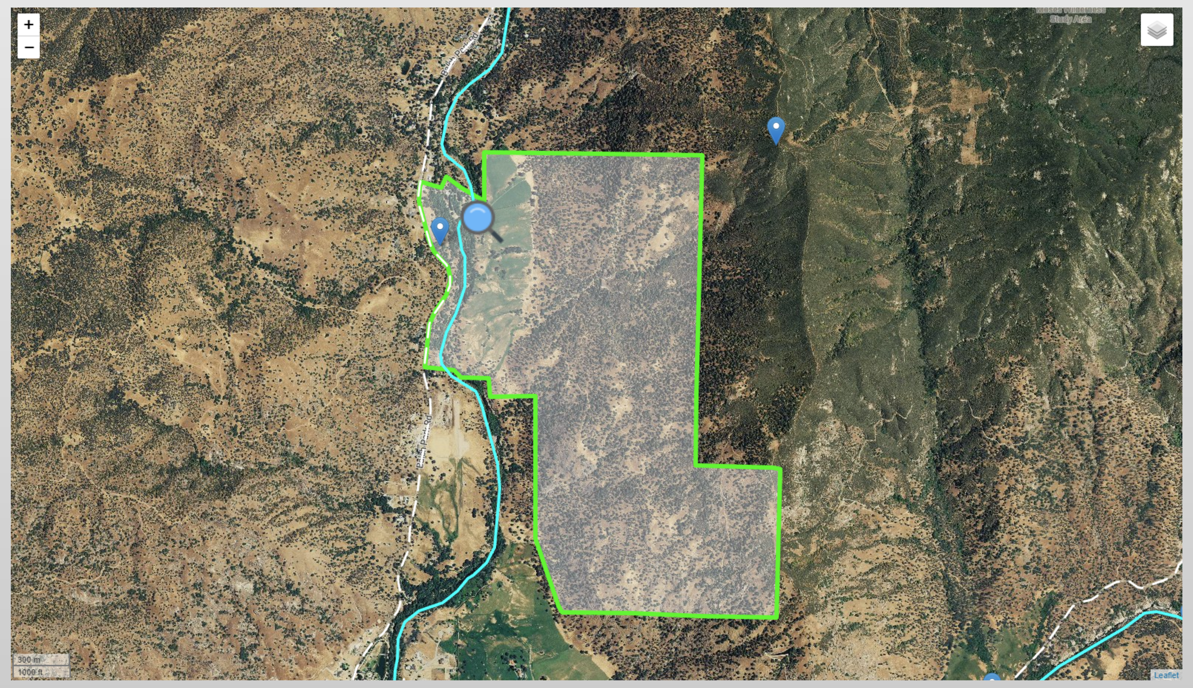


Figure 1. *A map highlighting the RRR property boundary, adjacent to the Tule River highlighted in blue, and encompassing our out study site symbolized by the magnifying glass.*

Data and Data Sources

Multiple datasets from various sources were acquired and complited to capture the entirety of our project. Rivers and creeks and road data for Tulare County were used for map enhancement. Multiple shapefiles pertaining to RRR were provided by the River Ridge Ranch Institute. Additionally, a dataset of tree species within the River Ridge Ranch was acquired from the River Ridge Ranch Institute. Multiple datasets were personally collected such as tree GNSS location data, multispectral UAV imagery, and LiDAR point clouds.

Table 1. *List of data and data sources used in the project.*

Dataset	Source
Rivers and Creeks	Tulare County
Road Data	Tulare County
Geographic POI	River Ridge Ranch Institute
Property Boundary	River Ridge Ranch Institute
Pasture Boundary	River Ridge Ranch Institute
Tree Attribute Data	River Ridge Ranch Institute
Tree Locations	Personally Collected
Multispectral UAV Imagery	Personally Collected
LiDAR Point Clouds	Personally Collected

Methodology

Our methodology can broken down into four components (Figure 2). All data that was collectd and acquired was processed, analyzed, and visualized.

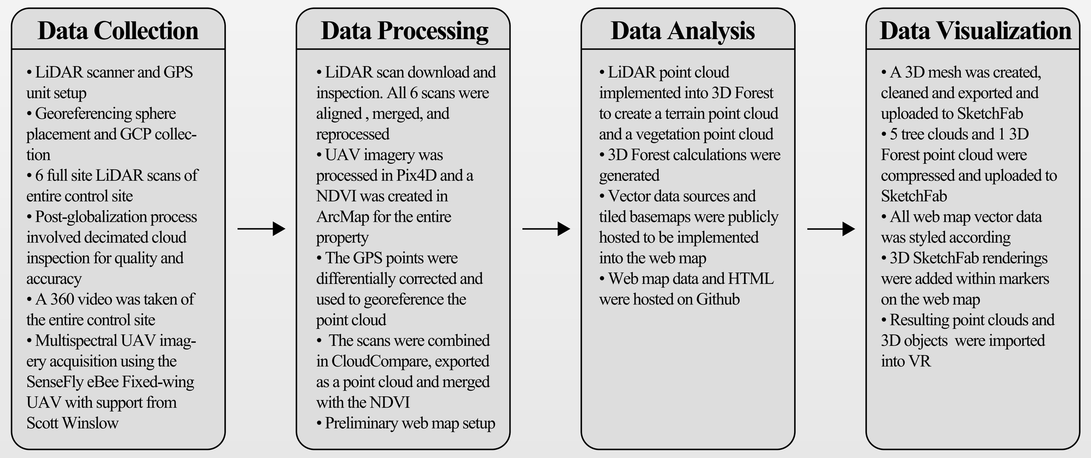


Figure 2. *Methodology spatial process model.*

Figure 3. *Initial LiDAR scanner and GPS unit setup (left). Aaron collecting GCPs on georeferencing spheres using the Trimble Geo7x to be used to georeference the LiDAR point clouds (right).*

Figure 4. *Noah scanning the entire control site with the ZEB REVO scanner from all angles. Scans took roughly 15-20 minutes to complete.*

Personally collected data was processed, analyzed, and visualized using a variety of software.The LiDAR point clouds were georeferenced using the sphere locations, and the UAV imagery was georeferenced using various GCPs dispersed across the property. All personally collected data was then loaded into a Leaflet web map for visualization, and the LiDAR models were implemented into VR.

Timeline

Our project was methodology based as seen by the long duration of methodological development in Figure 2.

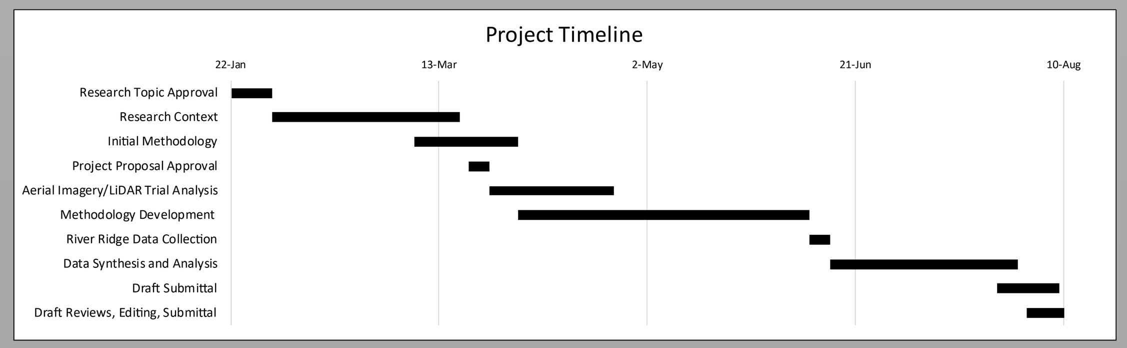


Figure 2. *Project Timeline.*

Results

The development of a variety of LiDAR visualizations captures the versatility of LiDAR for Blue Oak Woodland ecosystems.

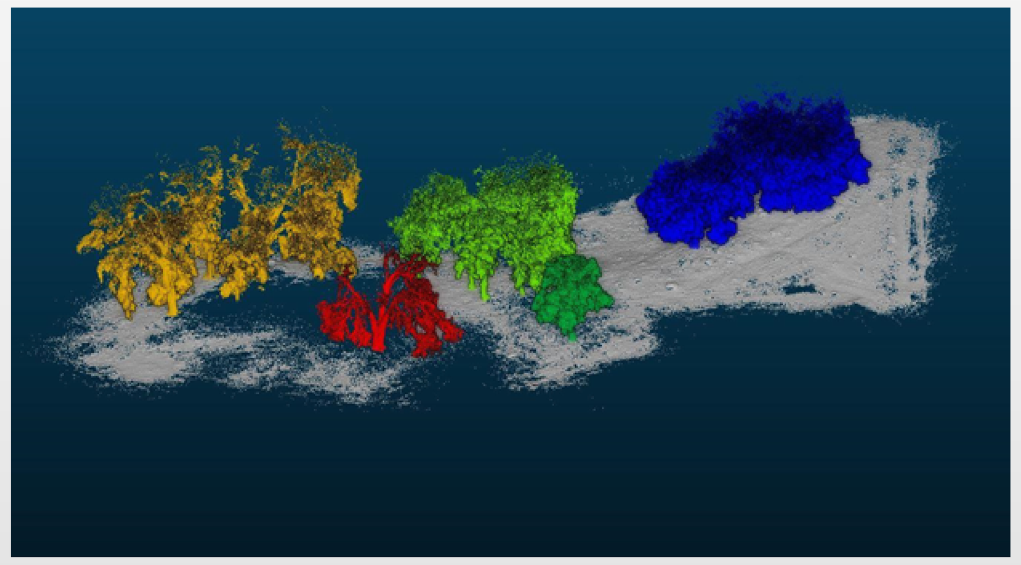
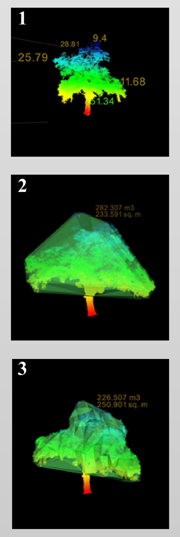


Figure 6. *Point cloud of the control site in Pature 2 at RRR. Composed of 5.9 million points that describe 13 individual trees of three different species.*



3D Forest Analysis	
Tree Point Cloud: Tree-LoneBlueOak_clean.pcd	
Number of Points	340,971
Tree Height (m)	9.4
Tree Length (m)	11.68
DBH HT (cm)	47
DBH LSR (cm)	51.34
Crown Height (m)	7.18
Crown Bottom Height (m)	2.22
Crown Total Height (m)	8
Length of Crown (m)	11.91
Width of Crown (m)	7.49
Concave Hull Volume of Crown (m^3)	226.507
Concave Hull Surface Area of Crown (m^2)	250.901
3D Convex Hull Volume of Crown (m^3)	282.307
3D Convex Hull Surface Area of Crown (m^2)	233.591

Figure 7. *3D Forest renderings and analysis of the Lone Blue Oak point cloud. Original (1), convex rendering (2), concave rendering (3).*

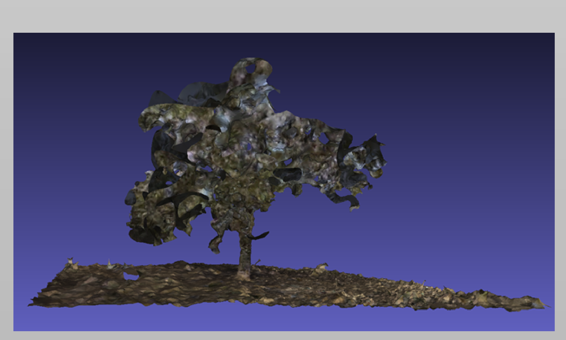


Figure 8. *Textured 3D mesh of the Lone Blue Oak.*

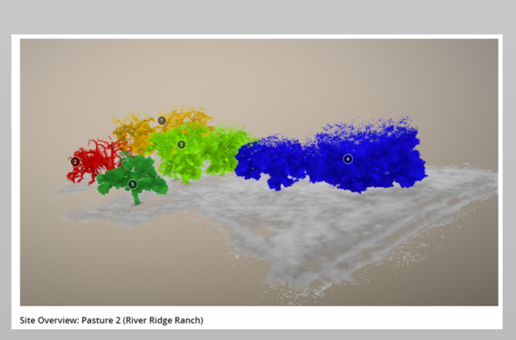


Figure 9. *Control site overview point cloud housed within SketchFab.*

Each SketchFab rendering is interactive within the web map popups and can be viewed full screen on our SketchFab account. An additional image of each tree is added within the popup

Figure 10. *Tree marker popup with SketchFab point cloud of individual tree (1). SketchFab point cloud for entire control site (2). 3D mesh of individual tree (3). NDVI raster overlay (4).*

The textured 3D meshes of the standalone trees within the control site were added into VR as 3D objects. A demo has been setup using the HTC Vive to view the 3D environment.

Discussion

Project and Results Signficance

The ZEB REVO LiDAR scanner posed as a valuable remote sensing device. The scans produced dense point clouds which led to the development of 3D meshes and objects. We were easily able to analyze the crown of a tree and receive the diameter at breast height (DBH) and height of the tree. The LiDAR renderings were also compatible with VR software and could be scaled appropriately. The open source nature of Leaflet allowed for easy implementation of hosted 3D renderings into a user friendly web map.

Project and Results Limitations

This project was limited due to several factors. Study site selection issues delayed methodological development and data collection, processing, analysis, and visualization and lead to major discrepancies between our proposed and actual project timeline. Our initial goal for multispectral aerial image acquisition was to use structure-from-motion (SfM) software to generate a 3D model and point cloud that were merged with the LiDAR point cloud. However, we were unable to acquire nadir, oblique, and horizontal imagery with suitable overlap for the SfM process. Additionally, had multiple software issues that hindered the processing of the LiDAR scans. Incorporating a VR platform into a geospatial analysis was problematic due to the lack of VR compatible GIS software. Adding a NDVI raster as a geoereferenced tile layer into the web map failed due to the large size of raster dataset.

Ethics

Our project's workflow has the potential to accurately measure a variety of metrics regarding plant health and tree structure to be used in conservation efforts.

Conclusion

Our project of developing a methodology utilizing LiDAR and multispectral UAV imagery for terrestrial ecosystem analysis was successful but in a limited manner. Proper data collection procedures were completed but could be enhanced given more time, research, and direction. Our methodology can be valued as a framework for future research utilizing LiDAR data and multispectral imagery in conjunction. While our project objectives were not fully met, we accomplished developing methods for visualizing 3D LiDAR renderings in a variety of ways. As LiDAR data and multispectral imagery become enhanced and more compatible, the opportunities for analyzing terrestrial ecosystems are limitless.

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For additional information please contact: Your name & email
Include a link to any project related content that you have made available online (e.g. datasets, web maps, videos, etc.).