

Integrating Aerial and Ground-based LiDAR in Appalachian Heritage Planning and Visualization

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PROJECT OVERVIEW

Introduction: The Natural Resource Analysis Center (NRAC) at West Virginia University is building a portfolio of integrated LiDAR (Light Detection And Ranging) projects in the areas of historic preservation, heritage planning, and visualization. Airborne, long-range, and close-range ground-based LiDAR technology is applied to the documentation of geographic areas and the construction of three-dimensional digital models at 'regional,' 'site,' and 'building/structure' scale. The models provide benefits to many disciplines, particularly resource management, historic preservation and landscape architecture creating enhanced opportunities for research. In accurately combining pointclouds, models provide for landscape documentation, analysis, planning and visualization.

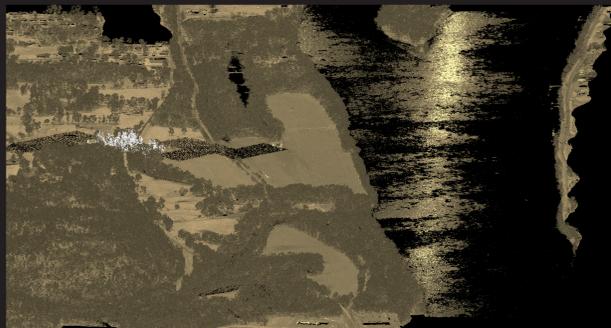


Figure 1: Axonometric view looking south down the Ohio River. The white form is the ground-based model integrated with the sepia tone aerial model.

Methodology: Data is collected using an airborne Optech ALTM 3100 and two ground-based scanners- a Riegl LPM i800-HA (800 meters range) and a Faro Photon 80 LS (77 meters range). Bringing together data from multiple instruments is a challenging operation that requires extensive investigation and trouble-shooting. The integration of various types of three-dimensional scanning data, specifically airborne and terrestrial, is only accomplished by utilizing differentially corrected GPS data, accurate interpolation and/or geo-rectification of distinguishable landscape features. Combining these technologies allows researchers to accurately map large scale terrain features with airborne data while being able to visualize, model, and analyze critical smaller features via static terrestrial LiDAR within one working project file.

Application- Henderson Hall Historic District Planning at Multiple Scales:

The narrative of the Henderson Hall Plantation (WV), near Williamstown, is connected to the Aaron Burr conspiracy as his plans for creating an independent nation germinated at Blennerhassett Island, ten miles to the south on the Ohio River. The Hendersons called attention to Burr's plans and contributed to his arrest and indictment. As this historic event has a spatial connection, modeling the larger environment to reveal and interpret this story is an application of the 'regional' scale pointcloud. The designation of the plantation property (approximately 80 acres) as a nationally significant historic district relies on the spatial organization of the plantation landscape, a 'site' scale model, as a key component of the integrity of the property. Aerial LiDAR was collected of the entire landscape creating a model for analysis and revelation of previously undocumented



Figure 2: The top image shows the aerial LiDAR pointcloud of the ground adjacent to the main building, Henderson Hall. The second image shows the colorized ground-based pointcloud placed into the aerial pointcloud.

forms, lines, and patterns. Landscape components that were documented in the aerial LiDAR include natural systems and features; spatial organization; land use; circulation; topography; vegetation; and archeological sites. Ground-based scans captured the 'buildings/structures' scale including the main Henderson Hall mansion, small scale features, as well as, a highly detailed model of the main structure's adjacent landscape. As new programming elements are proposed within the district, researchers are able to test management alternatives within the three-dimensional environment of the model. Visualizing change assists researchers in communicating design and planning decisions and the impacts of those changes on the integrity of the district.

LANDSCAPE COMPONENT ANALYSIS

As a tool for completing landscape and site scale cultural landscape analysis, LiDAR provides a level of detail not seen before. For this project the existing model for cultural landscape inventory and analysis as developed by the National Park Service was completed on-site and remotely using an integrated ground-based and aerial LiDAR pointcloud.

Natural Systems and Features: Natural systems and features of the landscape are integral to the overall identity of the plantation. The overall spatial organization of the plantation responded to its natural context most specifically in orientation and alignment with the Ohio River. The floodplain terraces also impacted the siting of the structures complex. The aerial LiDAR model captured these natural systems and the plantation development's response to them.



Figure 3: Overall view of the aerial and ground-based pointcloud data.

Spatial Organization: Through GIS mapping, georeferencing, and analysis of 1934 aerial photography as collected by the US Army Corps of Engineers the location of structures during the period of significance was determined. The LiDAR model allowed for very precise determination of current structure locations for comparison.

Land Use: Georeferenced 1911 US Corps of Engineers River Charts show land uses during the period of significance within the bottomlands area. The LiDAR model captured field patterns which were compared to 1911 and 1934 delineations. The texture of the modeled ground allows for determinations of management practices.

Closer to the Henderson home, land use in 1934 was compared to that in 2011. The patterning of the fields, paddocks and gardens within the cluster changed over time. Precise reestablishment of edges and fence lines to match 1934 characteristics is possible with the LiDAR model and use of GPS. The outline of a kitchen garden observed in 1934 aerial photography was identified using LiDAR and may guide accurate reconstruction.



Figure 4: Aerial LiDAR reveals circulation patterns connecting the terrace to the bottomlands and agricultural areas.

Circulation: The LiDAR model's detailed visualization of topography brought to light the palimpsest of former circulation patterns at different scales. The large scale patterns of the Baltimore and Ohio Railroad and River Road are clearly seen in current aerial photography. The Parkersburg-Marietta and Interurban electric train line on the north and west side of River Road, however, had been decimated over time. Researchers were

able to reconstruct the former railbed using aerial LiDAR. Researchers attempted to locate remotely the former steamboat landing on the Ohio River and a rock dike seen in 1911 River Charts. These physical forms were not discernible in the model however.

Circulation in proximity to the main complex of buildings was documented by examining 1934 aerial photographs and compared to 2012 LiDAR. The routes in 1934 connected to specific outbuildings and the barn complex to the south and east of Henderson Hall. These roads and paths, though considerably eroded over time, were located using the LiDAR model. This discovery will allow visitors to stroll the site as the Hendersons would have during their daily work activities adding to the sense of time and place during a visit.

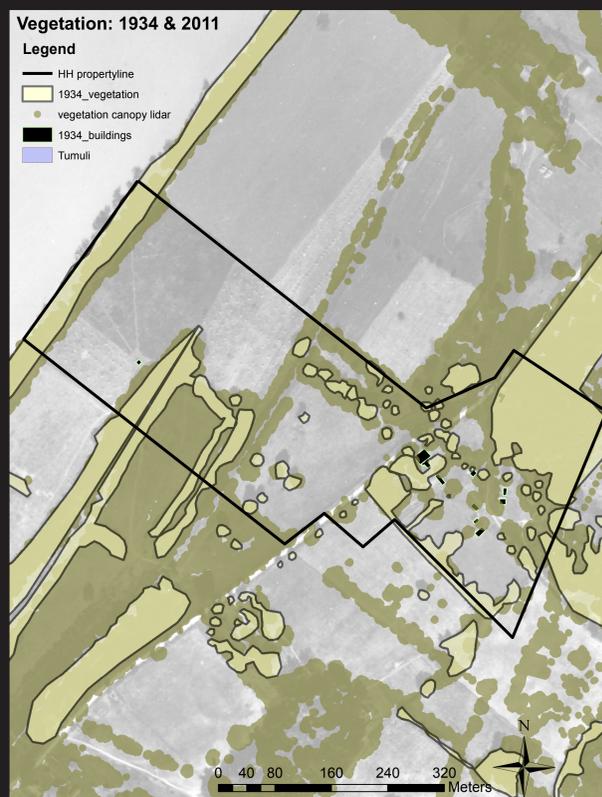


Figure 5: Aerial LiDAR was converted into a vegetation canopy model and brought into ArcMap. The vegetation was then compared to a digitized 1934 canopy layer.

Vegetation: The overall spatial organization of the property is strongly delineated by vegetation. Property edges where fences were established are the most common linear vegetative forms within the current property boundary. Using aerial LiDAR collected in 2012 and comparing vegetation patterns with 1934 aerial photographs shows a strong correlation between today and the period of significance; and allows for appropriate management strategies in site development.

Around the building complex, vegetation plays a similar role in defining edges and creating a strong sense of space. Ground-based LiDAR data, when integrated with the aerial pointcloud allows for three-dimensional modeling of the 'near' landscape. While the 1934 aerial photography does not show enough detail to determine integrity, historic photographs were analyzed to reveal contributing and non-contributing elements.

Buildings and Structures: Aerial LiDAR identified footings and foundations of structures present in 1934 aerial photography. Over time many of the outbuildings on the property had been moved. Returning displaced structures to their location during the period of significance is made possible through analysis of pointcloud data and the use of GPS. Researchers had sought to identify locations of former slave quarters through the use of LiDAR. This was not accomplished in the scope of this project possibly because of the limited size of the district in relation to the size of the original plantation. The once two thousand acre property has shrunk to 80 acres. Slave quarters were likely located a distance from the main Henderson Hall and thus are not currently a part of the core district.

Views and Vistas: Maintaining existing important views and reestablishing views that have been compromised by overgrowth of vegetation are important steps in the future development of Henderson Hall plantation. Section elevations cut from the integrated LiDAR clearly depict barriers to former significant views, in particular, views from the main house to the Ohio River and from the Ohio River to Henderson Hall, that tie the building to its conscientious siting and orientation during settlement. Vegetation patterns identified in 1934 aerial photographs would have

created more opportunities for visual connection to the river corridor. The LiDAR model will assist in management decisions with regard to vegetation and visual connections.



Figure 6: Colorized pointcloud collected with a ground-based scanner provides a very detailed model of the landscape and component elements adjacent to Henderson Hall.

Small Scale Features: Integrated ground-based scans accurately located small scale features adjacent to the main hall including a mounting block, wells, fencing, etc. Comparison of the location of these elements with historic photography allows researchers to plan for shifting of these elements in order to match more closely the period of significance. Visualizing these changes will be possible within the three-dimensional digital model created using LiDAR.

Archeological Sites: Three Adena tumuli are present within the district boundary. These forms are clearly seen in the integrated LiDAR model. Their exact location, dimensions and volume are measurable using the pointcloud. Other archeological sites identified and located in the model include ruins of former structures.



Figure 7: Tumulus A shown in relation to the main building at Henderson Hall.

Conclusion: The integration of aerial and ground-based LiDAR allows researchers an extraordinary level of detail in completing heritage planning and visualization projects. From the regional scale to the detail scale the collected data fits well with established models for cultural landscape research. NRAC will continue to gather, process, and apply three-dimensional data to support environmental and heritage planning; archeological surveying; and visualization/simulation efforts. Integrating aerial and ground-based LiDAR in constructing models fits the variety of scales that researchers and planners address in their work. As the Henderson Hall project progresses, demonstrating the interpretive potential of the model will become a key outcome of the project.

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Notes: Pointcloud imagery generated using Pointools software
Maps generated using ESRI ArcMap

Figure 8: Section elevation cut to show barriers to important views between Henderson Hall and the Ohio River

