La Mojana, Mother of Water

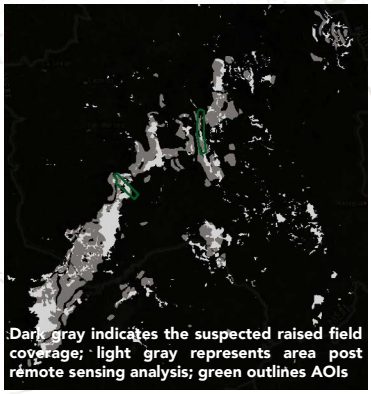
Entering Firm: GEO1 | Hawthorne, California
Client: Chris Fisher PhD | The Earth Archive | Fort Collins, Colorado

La Mojana Region | Colombia
February 2019

Objective

GEO1 was tasked with executing airborne lidar and nadir imagery acquisition of two remote sites of archaeological significance. Archaeologists aimed to confirm the scope of ancient settled landscape in the La Mojana region, using modern tools such as aerial imagery and lidar.

For acquisition, the GEO1 team utilized a helicopter mounted Riegl VUX-1LR in our custom dual sensor configuration, an Applanix AV410 IMU, as well as an integrated Phase One iXU-RS1000 with a 40mm lens for simultaneous acquisition of nadir imagery.



Dark gray indicates the suspected raised field coverage; light gray represents area post remote sensing analysis; green outlines AOIs

Other Consultants

Our team, Francisco Forero, Ron Chapple, and Phil Carter, worked with SADI, a local helicopter company in Bogotá, and pilot Stefan Mayer to plan and acquire the deliverables. Due to the remoteness of the location and the scale of the region, careful planning of flight logistics was needed to optimize and allow for sufficient time for acquisition.

Clemencia Plazas, a researcher who had completed field work in La Mojana and contributed to mapping the region in the past, also provided historical insight and analytical support to the project.

This study was produced in partnership with the Center of Archaeology and Remote Sensing (CARS), and The Earth Archive. CARS aims to improve and advance the use of lidar and other forms of remote sensing for archaeological research. Similarly, The Earth Archive recognizes the potential lidar offers in education, scientific studies, conservation efforts, and plans to create an open source platform of worldwide lidar. CARS and The Earth Archive provided analytical support, funding, and logistics to make this study possible.

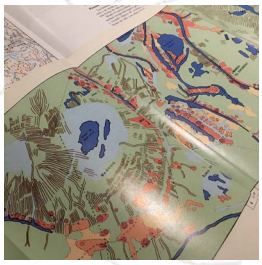
Client

Chris Fisher PhD., co-founder and director of The Earth Archive, was the principal investigator researching the differences between remote sensing techniques for archaeological research. Fisher was responsible for the remote sensing analysis that occurred post-processing.

Archaeological Significance

In the Northern coastal region of Colombia, on a floodplain flanked by the Magdalena, San Jorge, and Cauca rivers, lies some of the most fertile land in the country. Locals refer to it as La Mojana, after the folk legend of La Mojana, the mother of water.

At first glance, La Mojana is a marshland sparsely dotted with dwellings and, in some areas, plowed to grow crops. Historically, however, La Mojana was home to the Zenú, a thriving pre-Columbian civilization that adapted to the amphibious environment by constructing an ingenious system of canals across the river valley.

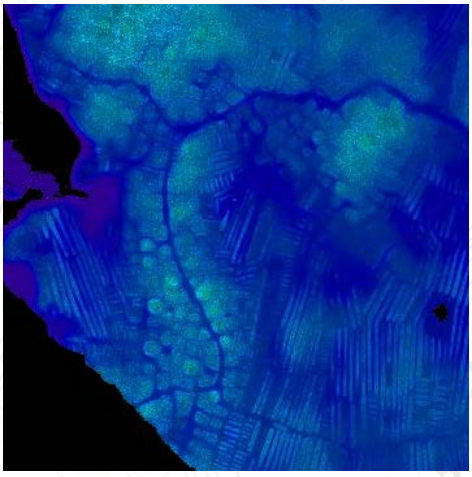


Through years of planning and developing sophisticated construction tools and techniques, a complex system of channels and raised fields emerged across the plains of La Mojana to form the foundation of Zenú culture. The excavated channels guided floodwaters from the adjacent rivers alongside embankments, upon which the Zenú built their homes and planted their crops. While protecting their community from floods, the channels also retained water after levels receded, mitigating the effects of seasonal drought. In addition to irrigation and flood protection, the waterways also facilitated travel across the plain and sustained fish for hunting.

Soon after the arrival of the Spanish, the Zenú culture all but disappeared, and the ancient irrigation system was abandoned. With the emergence of modern agricultural practices and settlements, the distinctive landscape of channels and raised fields across La Mojana faded.

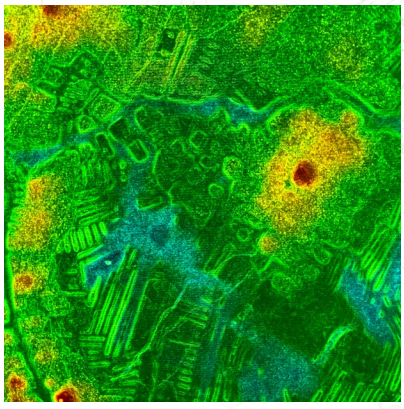
In 1966, an archaeological survey of the area identified approximately 80,000 acres of raised fields in La Mojana. Similar studies in other regions revealed more evidence of raised field agriculture, suggesting that pre-Columbian communities were larger, more complex, and had a more extensive ability and history of manipulating the landscape than previously thought. Despite the 1966 study, and the resulting discoveries about La Mojana's past, local inhabitants know little about the area's history or the legacy of La Mojana's distinct landscape.

Applying Remote Sensing



While lidar has proven to be an invaluable resource for archaeological research, lidar is often reserved for heavily forested areas or archaeological sites that encompass distinct landmarks, such as ancient dwellings and temples, or even manmade plateaus, like those GEO1 helped discover in and around Ciudad Perdida, Colombia. More subtle changes in landscape, such as those in La Mojana, are generally studied through visual interpretation of ground or aerial surveys. Recognizing the power of remote sensing, CARS and The Earth Archive have been promoting the use of lidar for more meticulous archaeological surveys.

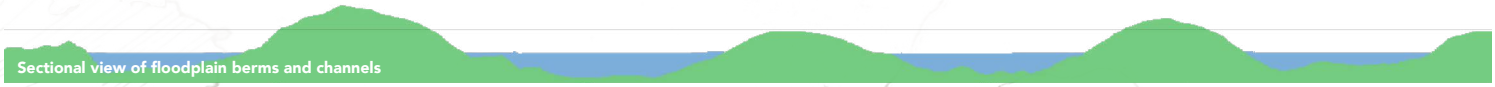
Chris Fisher embarked on a study to further analyze La Mojana for archaeological evidence using both satellite imagery and lidar. The objective was two-fold — examine La Mojana's landscape and build upon existing knowledge of raised agriculture and the Zenú society, as well as demonstrate how effective lidar can be in revealing archaeological evidence in non-forested areas and sites with little to no structural remnants.

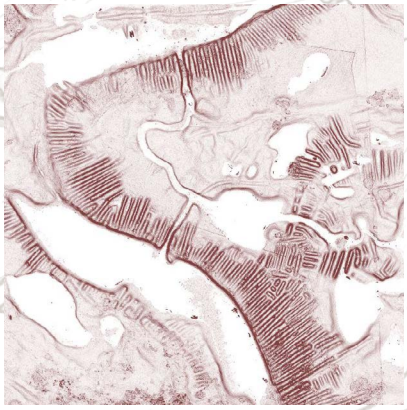


To demonstrate the advantage lidar can provide in environments similar to La Mojana, Fisher began by identifying raised fields, or sites that had been historically inhabited or cultivated by the Zenú, within two AOIs using satellite imagery. These AOIs were determined in conjunction with GEO1, after assessing areas where flooding was minimal and bare earth was visible. While satellite, and other visual aerial surveys, offer an excellent and often detailed view of non-forested archeological sites, they present several weaknesses that are overcome by lidar. A well known obstruction is cloud cover, however subtle topographical changes can also be easily concealed by low lying grasses. Furthermore, a significant but often overlooked disadvantage in using aerial imagery in this context is the lack of literature or established methodology on how to identify remnants of an agricultural landscape from visual surveys.

After all raised fields identified with aerial imagery had been marked, GEO1 was then tasked with acquiring lidar data and nadir imagery for these two AOIs, a total of roughly 5,000 acres.

The flight crew spent a week to plan, acquire, and process the data. This also involved determining logistics to optimise efficiency and quality of data capture. Acquisition was completed in a day, and an additional three days were spent processing the data. The final data deliverables were LAS files and 100 megapixel RGB nadir imagery of the areas of interest. In total, it took a week to plan, acquire, and process the data.





Post-Processing Analysis

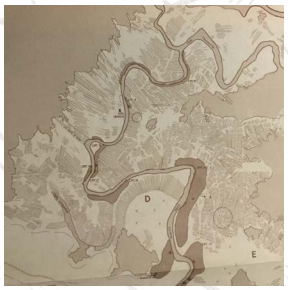
Using the lidar point cloud, Fisher first produced a Digital Elevation Model and then a Red Relief Map to determine shading throughout the surveyed area. This method of data visualisation allows subtle changes in the landscape to appear more striking and in turn more easily identifiable.

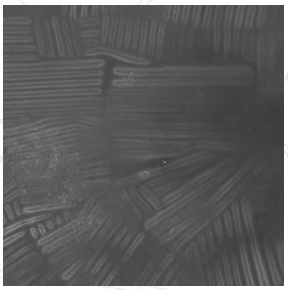
With the lidar data, 713 additional acres of raised fields were detected that had not been identified using satellite imagery — nearly 23% of the total area of raised fields measured using lidar. This new insight into the extent of waterways and raised fields in La Mojana has the potential to reshape previous notions of population size, density, and complexity in the area. The increase in archaeological evidence extracted through lidar, when compared to the sites identified with satellite imagery, serves as a clear indicator that lidar is a crucial supplement to studies of archaeological landscapes in non-forested areas. Furthermore, the findings in La Mojana reinforce the understanding that land in the pre-Columbian Americas was not untouched or unexplored, but instead home to complex societies that manipulated, managed, and thrived off the land.

Outcome

The lidar data that was collected and processed by GEO1 proved instrumental to the conclusions made by Fisher's study. Not only was the data used to identify key areas in La Mojana that had been excavated and settled upon by ancient cultures, but also served as a foundational piece of evidence in demonstrating the power and versatility of lidar in archaeological studies.

The data acquired by GEO1 was also monumental in advancing research in the area, building upon the only existing survey records — hand drawn maps from 1966. After successfully acquiring and delivering processed data for the La Mojana study, GEO1 was selected to continue working alongside The Earth Archive in their research endeavors.





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