



Project Report

LiDAR Scanning of Pedro and Teofilo Trujillo Homesteads

Project Team

Ekaterini Vlahos

Associate Professor, Architecture & Planning
Director, Center of Preservation Research

kat.vlahos@ucdenver.edu

Campus Box 128, PO Box 173364
Denver, CO 80217-3364

p 303.556.6502
f 303.556.3687

Michael Nulty

Documentation Coordinator

michael.nulty@ucdenver.edu

1512 Larimer Street, Suite 750
Denver, CO 80202

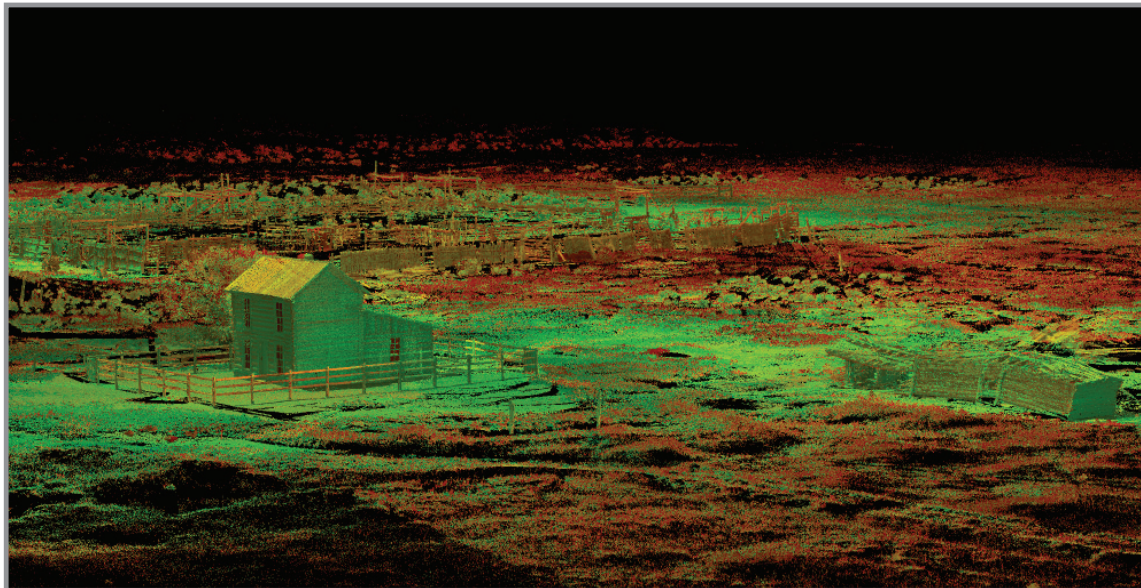
p 303.315.5871
f 303.315.5872

Julia Ausloos

Research Assistant

julia.ausloos@ucdenver.edu

1512 Larimer Street, Suite 750
Denver, CO 80202



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November 1, 2012

[1] Project Overview

National Park Service Contacts

Christine Whitacre

Intermountain Regional Office
Heritage Partnerships Program
12795 W. Alameda Parkway, PO Box 25287
Denver, CO 80225-0287
christine_whitacre@nps.gov
p 303.969.2882

Kathy Tonnessen

NPS Research Corrdinator
College of Forestry and Conservation
University of Montana
Missoula, MT 59812
kathy_tonnessen@nps.gov
p 406.243.4449

Bill TallBull

Grants and Agreements Specialist
National Park Service
12795 W. Alameda Parkway
Lakewood, CO 80228
bill_tallbull@nps.gov
p 303.969.2891

Final Report Delivery Contact

Lisa Gerloff

Executive Coordinator
Rocky Mountains Cooperative Ecosystem Studies Unit (RM-CESU)
University of Montana - College of Forestry and Conservation
lisa.gerloff@cfc.umt.edu
p 406.243.5346
f 406.243.4845

Project Location

Trujillo Homesteads
Great Sand Dunes National Park
11500 State Highway 150
Mosca, CO 81146-9502

Project Dates

On-Site Scanning:	June 17, 2012 - June 21, 2012
Post-Processing:	July 2012
Deliverable-Processing:	September 2012
Project Deadline:	December 31, 2012
Final Delivery:	November 1, 2012

Proposed Project Scope

- 3 Days on-site scanning
- 10-16 Scan Locations
- HDR Photography for Each Scan Location
- Produce 5-10 Scan Shots

Actual Project Outcome

- 4 Days on-site scanning
- Acquired 14 Scan Locations
- 14 HDR Panoramic Images captured
- 17 Scan Shots were created
- 2 Fly-Through videos were created
- Final Report was created to illustrate scanning and post-processing procedures



[2] Site Evaluation and Assessment

The Trujillo Homesteads, located on land owned by The Nature Conservancy and within the authorized boundary of Great Sand Dunes National Park and Preserve, recently received National Historic Landmark designation on January 3, 2012. The Trujillo Homesteads exceptionally represent the expansion of Hispano-American settlement in the part of the American Southwest newly-acquired by the United States in the 1848 Treaty of Guadalupe-Hidalgo. Teofilo and Andrelitta Trujillo built one of the largest and wealthiest Hispano ranch operations in the San Luis Valley. Their son, Pedro Trujillo, adapted to the increasing dominance of Anglos in the area by raising only cattle, building a two-story log house on his own homestead, and speaking English. The homesteads represent Hispano settlement and the preservation of traditional Hispano culture on the frontier, as well as the impact of cultural exchange with Native Americans. In December 2011, the Advisory Board of the National Park System voted to recommend National Historic Landmark designation for the Trujillo Homesteads. On January 3, 2012, the Secretary of the Interior Ken Salazar officially designated the Homestead a National Historic Landmark.

Archeological evidence at Teofilo's homestead is all that remains but the site has been intensely studied and documented to complete the National Historic Landmark nomination. Pedro's homestead including his 2-story log house and contributing structures were also documented and researched to complete the nomination. The 2-story log house at Pedro's site has been restored but many of the contributing structures remain in situ and have not been restored to original conditions. The park has received RM-CESU funds to collect data at the Trujillo homestead site with the use of Terrestrial LiDAR scanning equipment and the creation of a virtual imagery tool of the site to be housed on the park's website. This information is crucial to interpret a publicly inaccessible site of significant value to the collective history of Latinos in the San Luis Valley. This data will help protect and preserve these resources for future generations, and will assist students in historic preservation by making these materials available on a public web site.

The College of Architecture and Planning at the University of Colorado Denver, an RM-CESU partner, has been identified as a partner to complete this project because of their experience with the use of scanning technologies to generate highly detailed 3D models to document, analyze, and preserve rural historic sites and large cultural landscapes in the state. They have also been selected for their commitment to use staff and students to participate in this documentation, analysis, and preservation of built environments and cultural and natural landscapes. This commitment fits well with the park's mission to enhance the understanding and appreciation of culture using park resources and material culture while also using park resources as tools to interpret untold stories of significant value to the local community and other park visitors.

* This information was taken from the National Park Service grant form



[3] Data Gathering and General Site Procedures

Onsite Description of Technical Processes

Using LiDAR to digitally scan a site and/or structure is different for every project. Depending on the desired outcomes and deliverables expected the strategies involved can vary widely. For the most part though, the equipment we bring is similar. Besides the Leica made Scan Station 2, we use a PC laptop to control the scanner, a standard Ethernet cable to connect the two, a number of HDS targets on tripods, two large batteries to power the scanner, a tribrach, Nodal Ninja, Digital SLR camera, and a separate, heavy tripod that supports the 40 pound, fully robotic scanner. We also bring a gas-powered generator with us to most sites, as they tend to be remote. The generator powers the laptop and charges the batteries used for the scanner.

Once a thorough site inspection has been completed so that scan locations and target locations have been identified the scanner is set up in its first location. These scan locations are determined based on efficient data collection and wide coverage of the site and or structure that is being documented. Once the scanner is ready it is connected to the PC laptop via the Ethernet cable. We use a software program called Cyclone (made by Leica) to control the scanner with the laptop. After the appropriate settings are established the scanner begin operation. The scanner is equipped with a digital camera (low quality) inside and has the capability of taking a nearly 360-degree image from the perspective of the scanner. This allows us to see what the scanner sees from the laptop. We can now see what the scanner sees and can begin to select what to scan through this digital image provided to us through the Cyclone software interface.

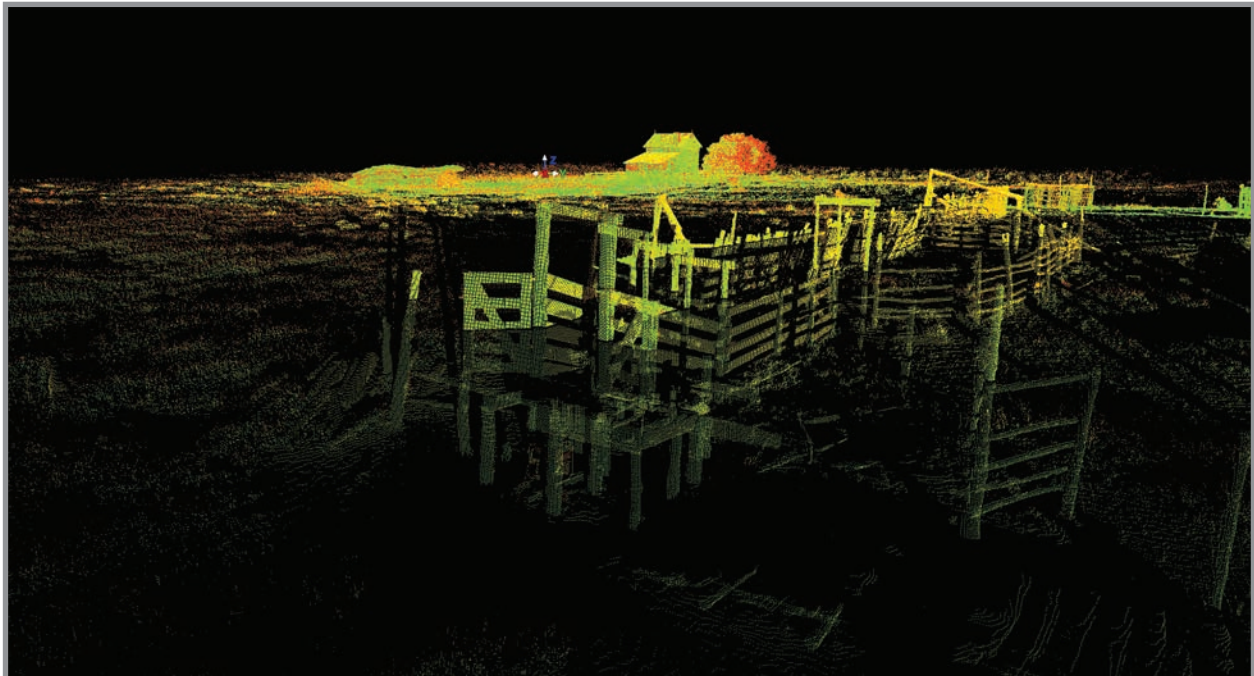
Once we can see this preview image the scanning can begin. Depending on how much and at what point densities we are scanning a scan can take anytime between 15 minutes and several hours to complete. The scanning itself is not the only thing going on at each scan location. Within each scan we are also acquiring HDS (High Definition Surveying) targets. These are very precise points in space that allow us to tell the scanner where it was in space in relationship to the other scan locations. This is important for post-processing efforts once data collection is complete. The process telling the computer where each scan location was in relation to the other scan locations is called registration. This is when we tie all the scans together to create a completed 3D model.



Scanner in front of Pedro Trujillo log cabin house

Once scanning and target acquisition is completed we use the Digital SLR camera to collect better image information than the scanner can. We take the time to collect HDR (High Dynamic Range) photography at each location. HDR allows us to capture high quality images that give us more information than standard photography. We also collect RAW images for greatest quality and color range. We collect a 365-degree sphere of images that we later stitch together and texture map onto the point cloud data for a more photo-realistic 3D model.

Once scanning and HDR photograph is complete at each location the process of moving to the next location must be completed. During the process of moving all the equipment related to the scanning process it is critical to make sure that they stay out of the way of the scans. We often are shifting around the generator, battery boxes, scanner boxes, etc. to ensure we are only capturing the site and its structures. As we move equipment around we are also being very cautious not to shift targets. These HDS targets are so accurate that even an accidental touch can shift the target out of position giving you errors in the post-processing effort. The target locations are also very specific so they can be seen from multiple scan locations. At each location the scanner is disconnected, powered down and moved with care.



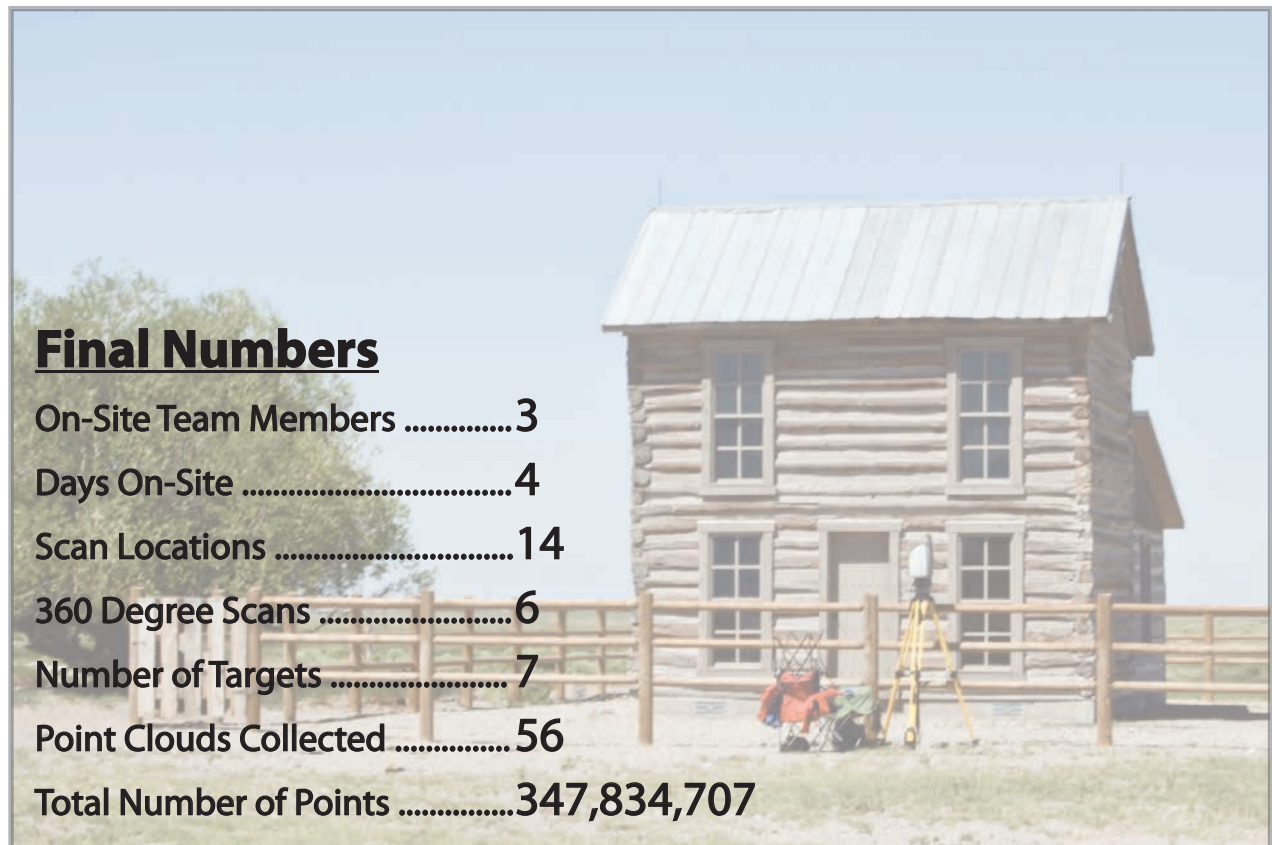
View in Cyclone of scan data with intensity values of Pedro Trujillo corrals with the log cabin in the background



Procedures and Scanning Effort Details

The University of Colorado Denver scanned the Trujillo Homesteads using a Leica Scan Station 2 Scanner from Monday, June 18th through Thursday, June 21st 2012. Kat Vlahos, Director of the Center of Preservation Research (CoPR), and Mike Nulty, documentation coordinator at CoPR, began scanning the Teofilo Trujillo Homestead site on Monday, where they finished and were able to move onto the Pedro Trujillo site by Tuesday. On Wednesday, CoPR research assistant, Julia Ausloos joined the team and helped Mike finish up the scanning efforts at the Pedro Trujillo Homestead site.

In total, fourteen different scan locations were acquired between the two homestead sites, and six of those locations consisted of 360 degree scans to acquire the entire surrounding context of the homesteads. In addition to scanning, 14 panoramic images were also captured at each location to be used for photo texturing during post processing. Seven HDS targets were used throughout both homestead sites as control points that would later help tie scan locations together. Each scan location took anywhere from 12 minutes upwards to about 75 minutes, depending on the scan density acquired. (please see field notes for a more detailed scan schedule).



Final Numbers

On-Site Team Members	3
Days On-Site	4
Scan Locations	14
360 Degree Scans	6
Number of Targets	7
Point Clouds Collected	56
Total Number of Points	347,834,707

Site Photos



Scanner acquiring HDS target in the background



View of Pedro Trujillo house and stable with scanner in the foreground

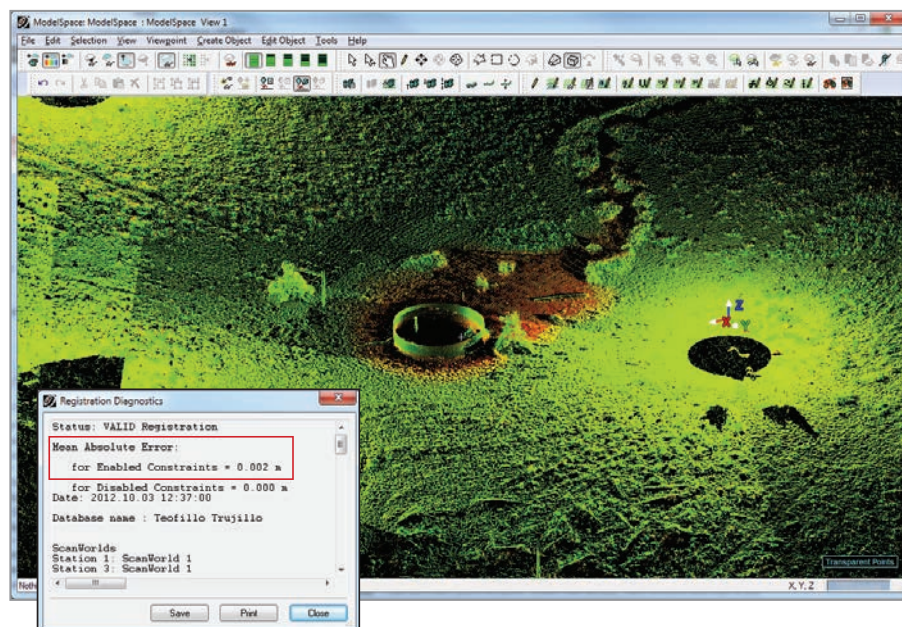
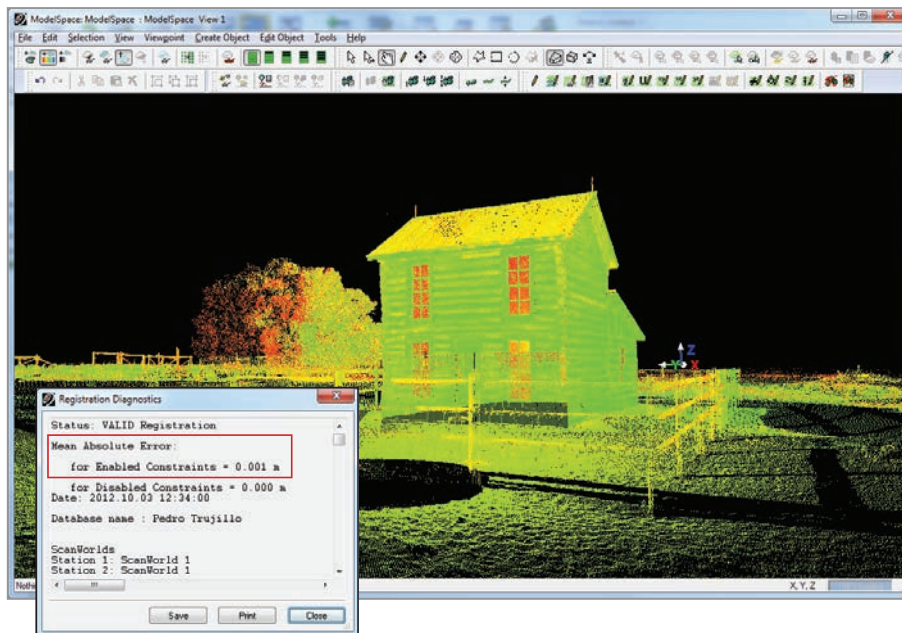


Mike Nulty running the scanner in front of the Pedro Trujillo house

[4] Data Management

Initial Post-Processing

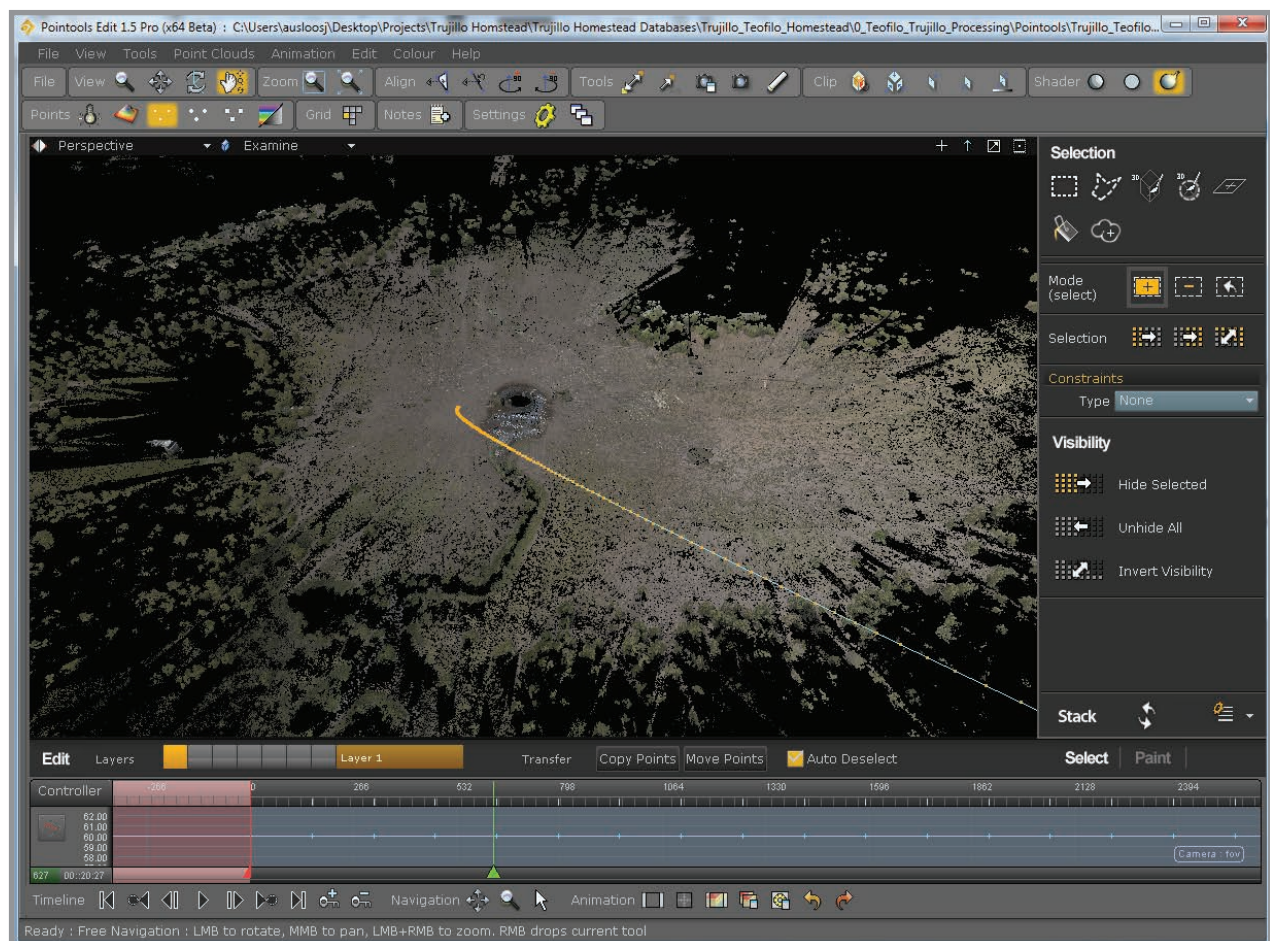
Towards the middle of July initial post processing of the Trujillo Homesteads began. All 14 panoramic images were processed using PTGui software. The panoramic images were then used to photo texture each scan location making the data look more photo-realistic. After phototexturing, all 14 scan locations were registered together using a combination of target and feature registration with a Mean Absolute Error (MAE) of only .001 m for the Pedro Trujillo Homestead, and .002 m for the Teofilo Trujillo Homestead. (See images below) This exceeds CoPR's standard, which is to have a MAE no greater than .005 m.



Deliverable Processing

Deliverable processing for the Trujillo Homesteads began during the weeks of initial post processing, but then picked up again during mid-September. When the 14 panoramic images were initially processed to be applied to each scan location, they were also processed to create QuickTime (QTVR) videos. The purpose of these QuickTime videos is to allow for a virtual tour like experience at each scan location. Three different QTVR movie file sizes were saved for each scan location to provide flexibility in how these virtual tours can be disseminated.

The deliverable processing that took place in mid-September includes bringing the registered scan data from Cyclone into a program called Pointools. Pointools provides better rendering capabilities of the scan data, and ultimately offers higher quality visualizations of the point clouds within the scan data. Pointools was used to create the 15 Scan Shots, as well as a fly-through for each homestead. The fly-through is a video that allows viewers to “fly through” the scan data viewing it from multiple angles as if they were at the site.



Screen shot of Teofilo Trujillo Homestead fly-through being created in the Pointools program

Archiving

Full copies of raw and processed data will exist in several places and media. UCD will have a copy of the data backed up on an external hard drive as well as on a local computer. A copy of the data will eventually be housed on DVDs located in a different geographic location from the hard drives as extra protection against loss. The data will also be delivered to the contractee Milender White Construction Co. for their records. UCD is not contracted to store or backup the data for any amount of time.

Issues of data storage and archiving are complex. Throughout all industries change to data and how it is managed occurs as fast as the technologies that create it. This makes planning for the future of data management very difficult because it is so difficult to know what the data landscape will look like. Not only can we not provide long term solutions (more than 30 years) based on current available medias and strategies but understanding how changes in the future will alter and affect current data are impossible to outline. A clear example of this is how we deal with floppy disks now – we can't.

1. The University is not in a position to archive data for long periods of time.
2. CoPR is responsible for data until it is handed over to client/partner.
3. CoPR maintains a 1 year and 5 year archiving and storage strategies but they are not fool-proof back-up strategies.
4. Data collected and managed by CoPR is stored on a remote server for the first year after collection. A copy of the data is also stored on a local computer and an external harddrive. After one year most data is copied onto a DVD and stored off site. The reliability of data stored on DVD media is variable.
5. CoPR will maintain the data as best as it can for research and academic purposes but should not be relied on as an ultimate backup.
6. CoPR can offer solutions from other providers for more permanent data management solutions.



[5] Data Representation

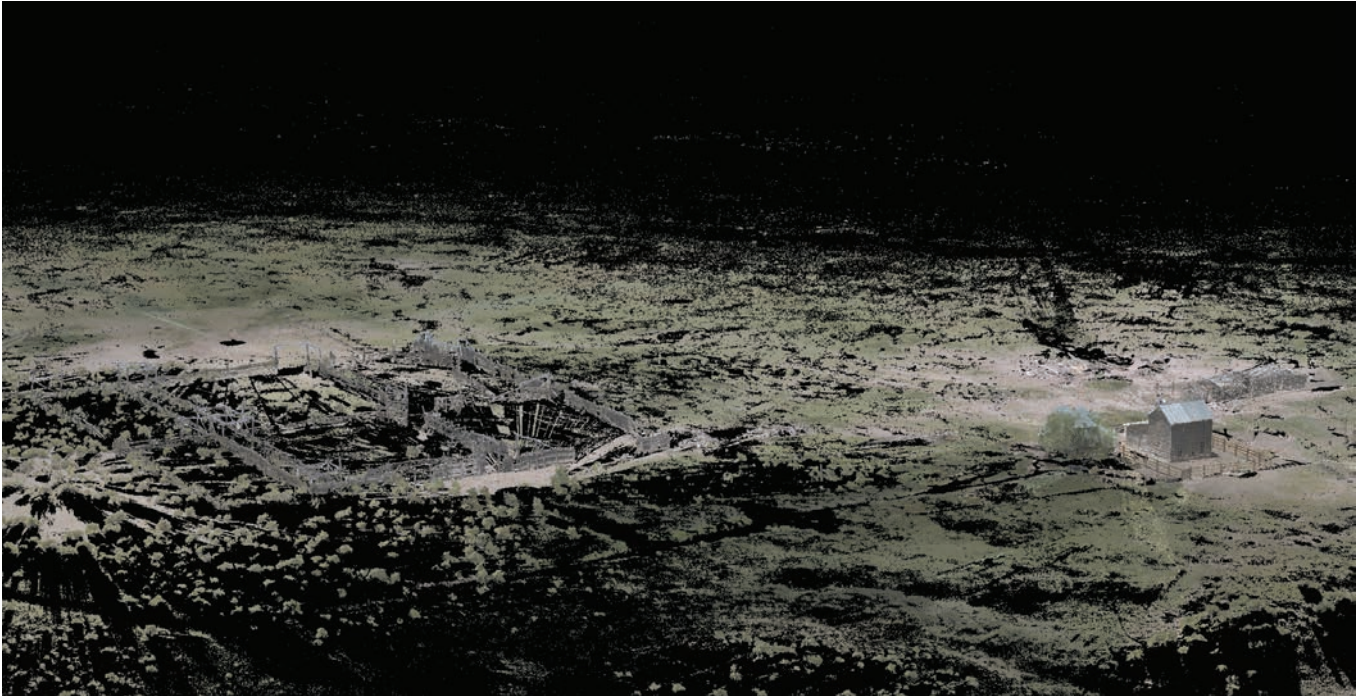
Documentation of the Pedro and Teofilo Trujillo Homestead sites is crucial in the interpreting of a publicly inaccessible site of significant value to the collective history of Latinos in the San Luis Valley. The hope is that this data will help protect and preserve these resources for future generations. In the end, the goal of this project was to simply document both homestead sites through LiDAR 3D Laser Scanning so that there will be a record of what exists at the current time.

For this project alone, a number of deliverables were created as an initial representation of the scan data, including HDR panoramic images turned into QuickTime videos, photorealistic and scan intensity scan shots, and digital fly-through videos. However, in addition to these deliverables the scan data collected during this project provides opportunities for other deliverables to possibly be created in the future when time and funding are available. Some examples of these additional deliverables may be HABS drawings including plans and elevations, or a website to include all deliverables created to date with additional information.

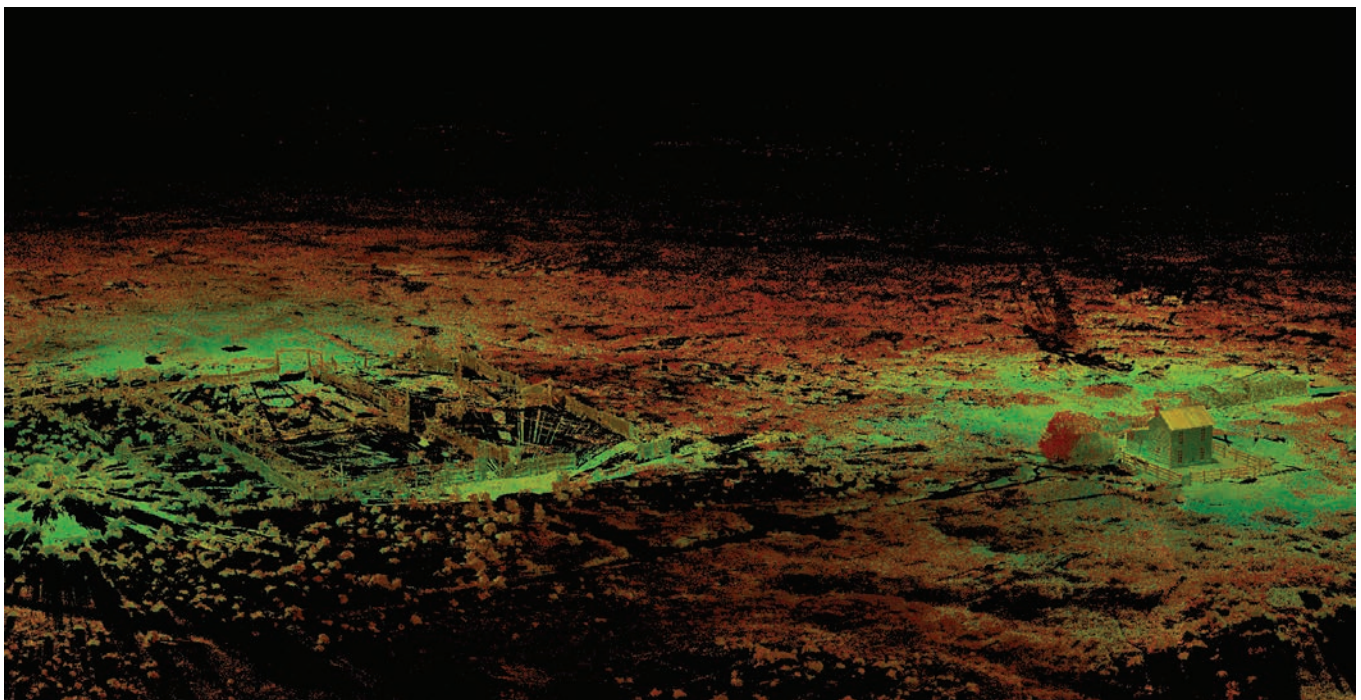


[6] Scan Shots

Pedro Trujillo Homestead

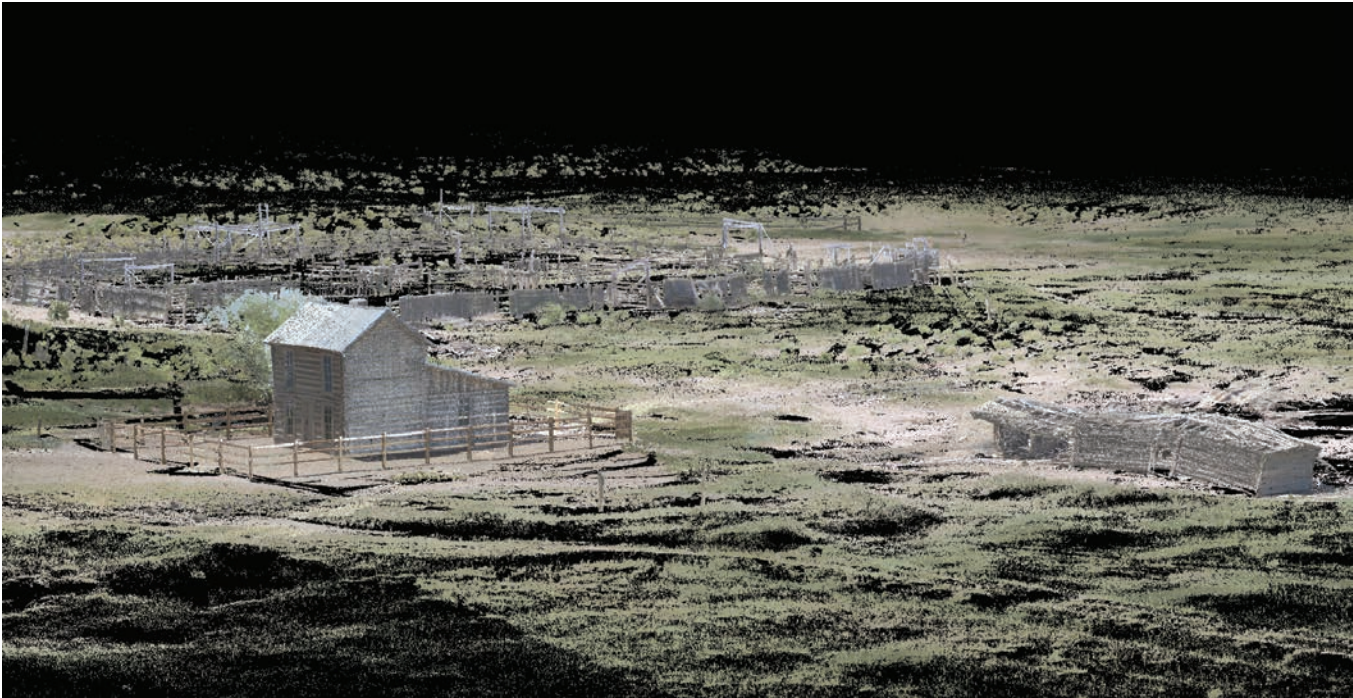


Perspective view of the the entire Pedro Trujillo Homestead site



RGB and intensity value scan data perspective view of the the entire Pedro Trujillo Homestead site

Pedro Trujillo Homestead



Perspective view of Pedro Trujillo two-story log cabin and stable with corrals in the background

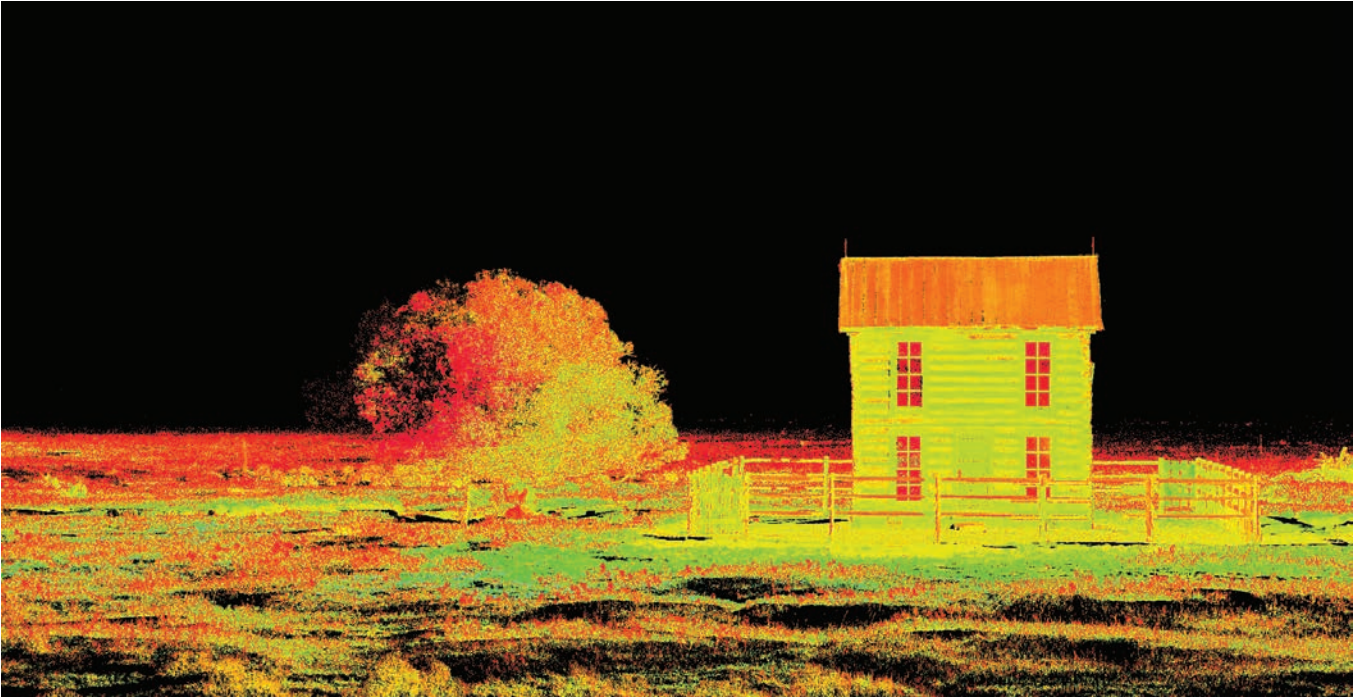


Perspective aerial view of Pedro Trujillo corrals

Pedro Trujillo Homestead



Front view of Pedro Trujillo two-story log cabin

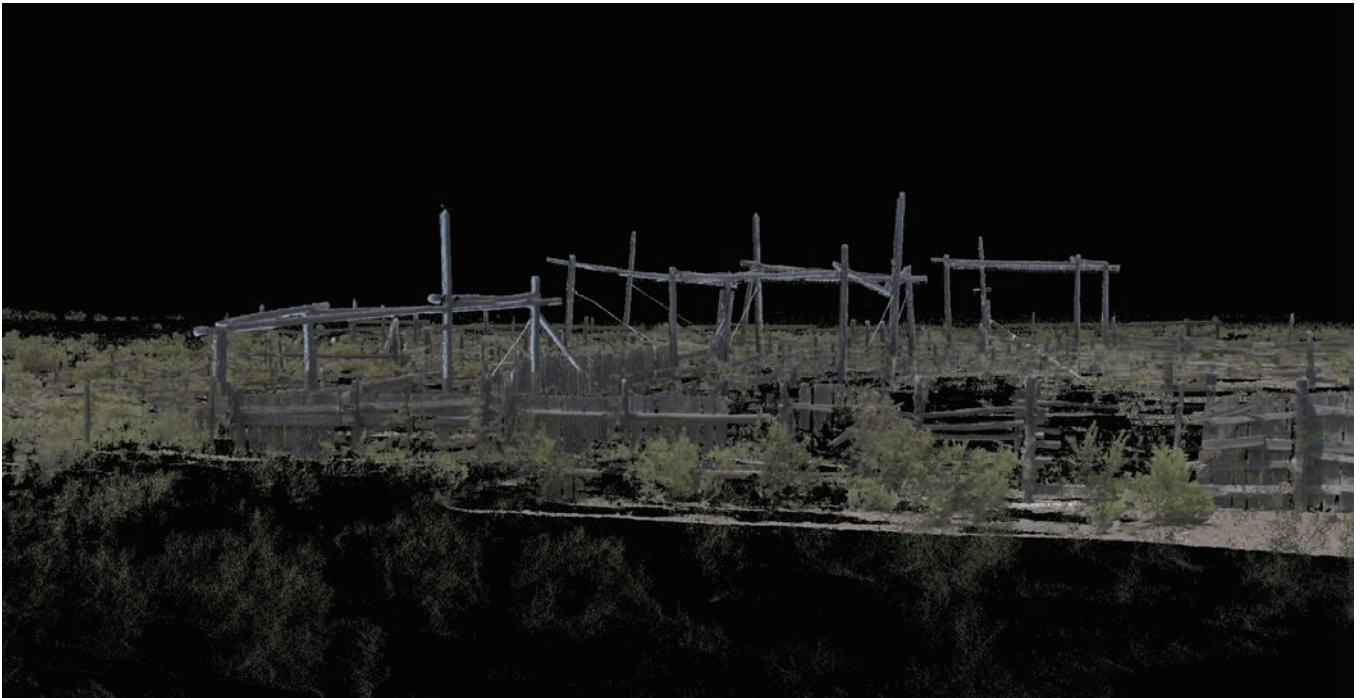


Intensity value scan data of front view of Pedro Trujillo two-story log cabin

Pedro Trujillo Homestead



Front view of Pedro Trujillo stable structure

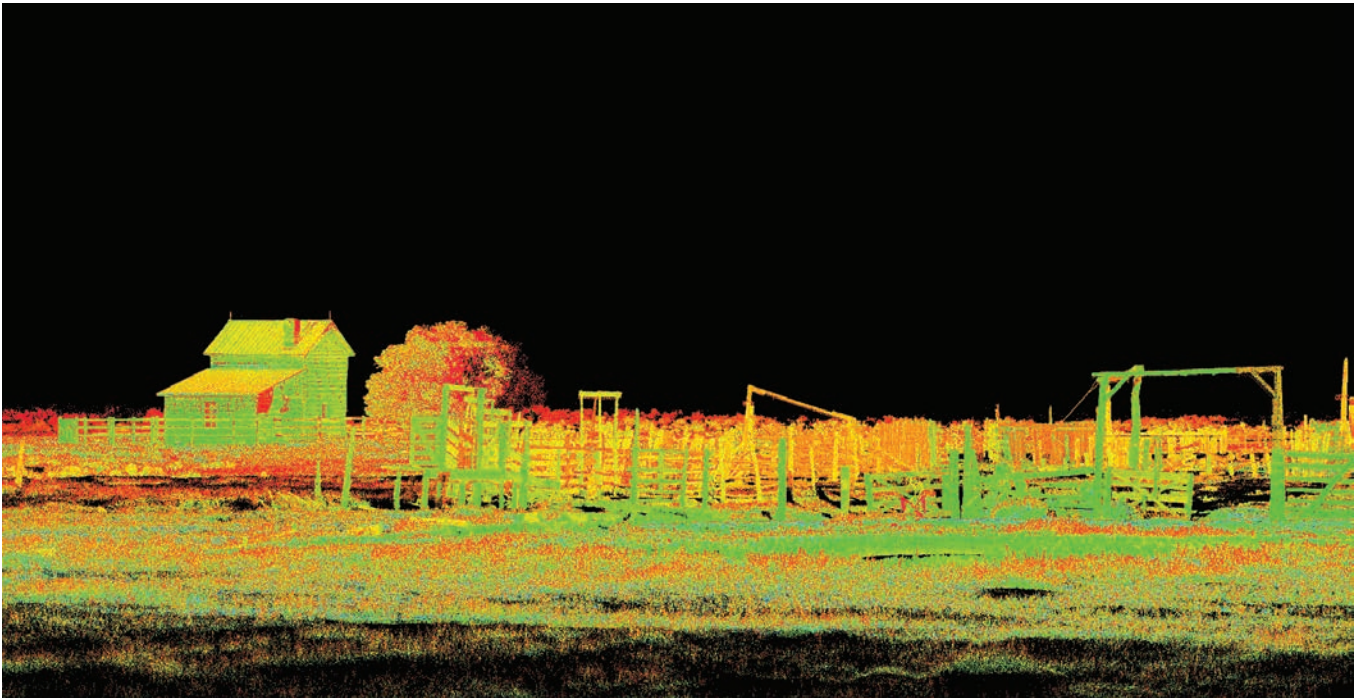


Close-up view of Pedro Trujillo corrals

Pedro Trujillo Homestead



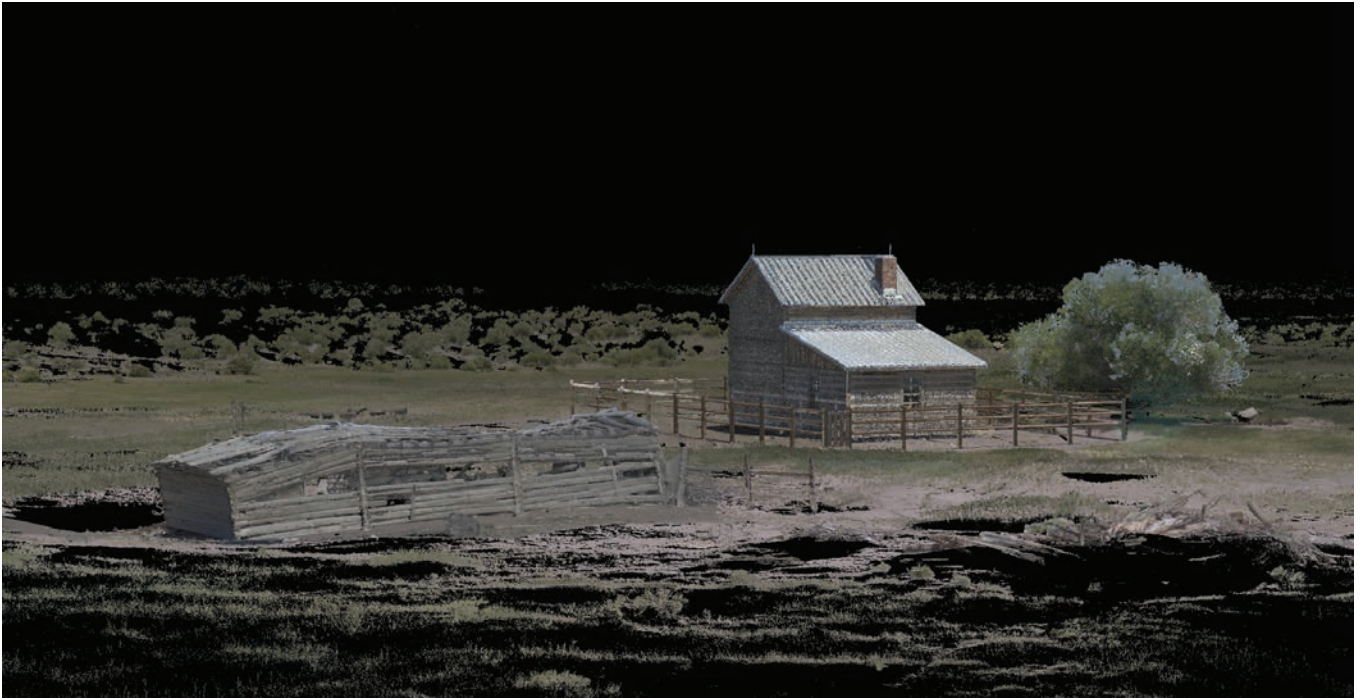
View of Pedro Trujillo corral with the log cabin in the background



Intensity value scan data of Pedro Trujillo corral with the log cabin in the background



Pedro Trujillo Homestead

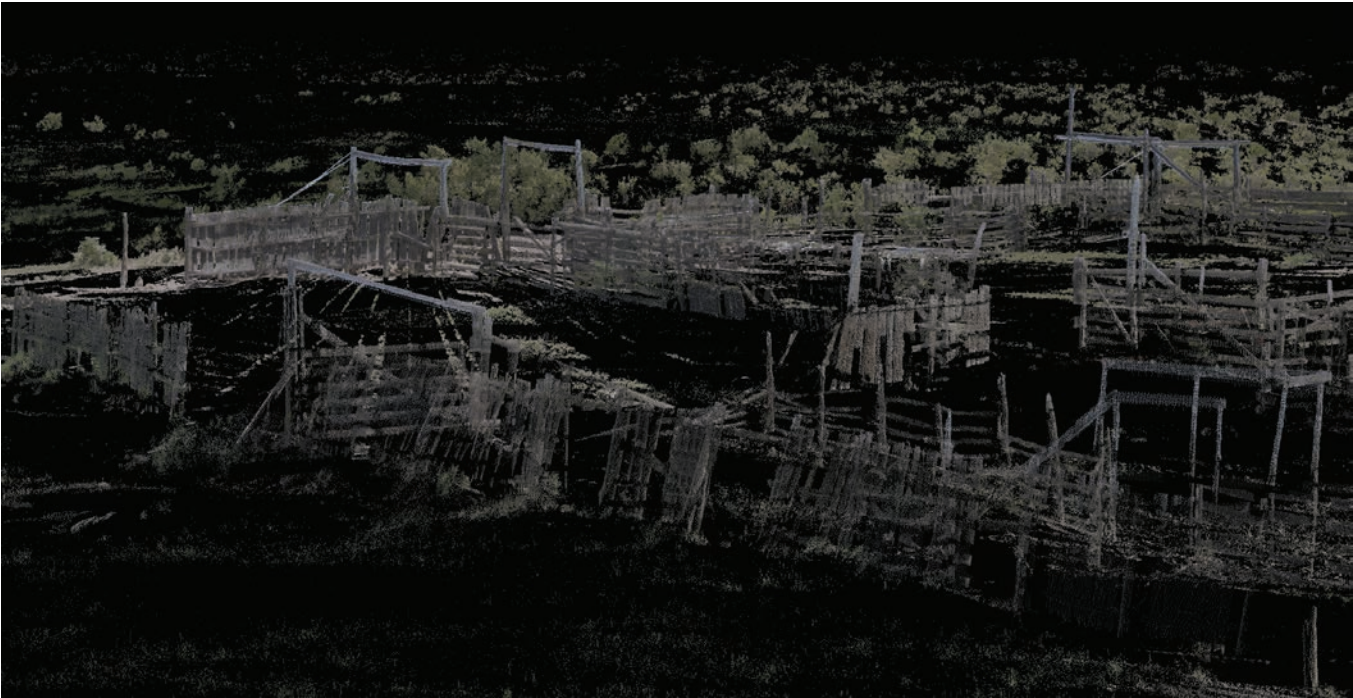


Back view of both Pedro Trujillo stable and log cabin

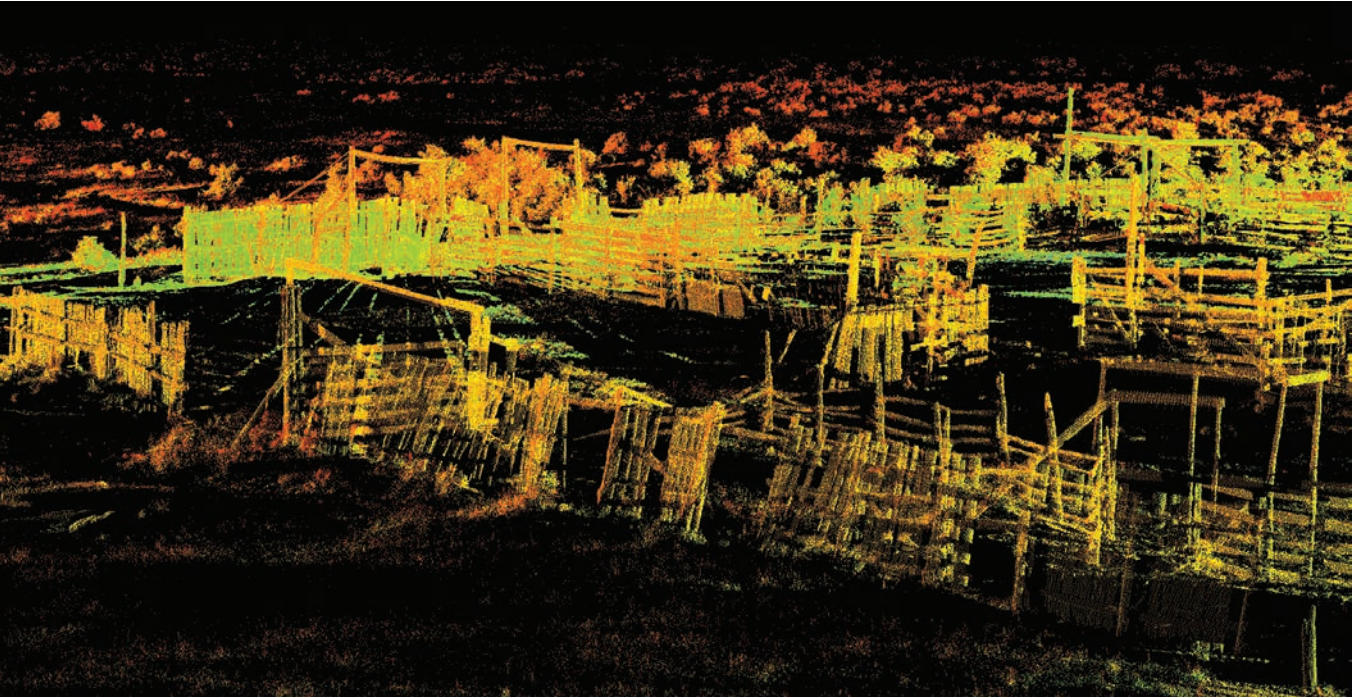


Close-up view of Pedro Trujillo corrals with log cabin in the background

Pedro Trujillo Homestead



View of Pedro Trujillo corrals

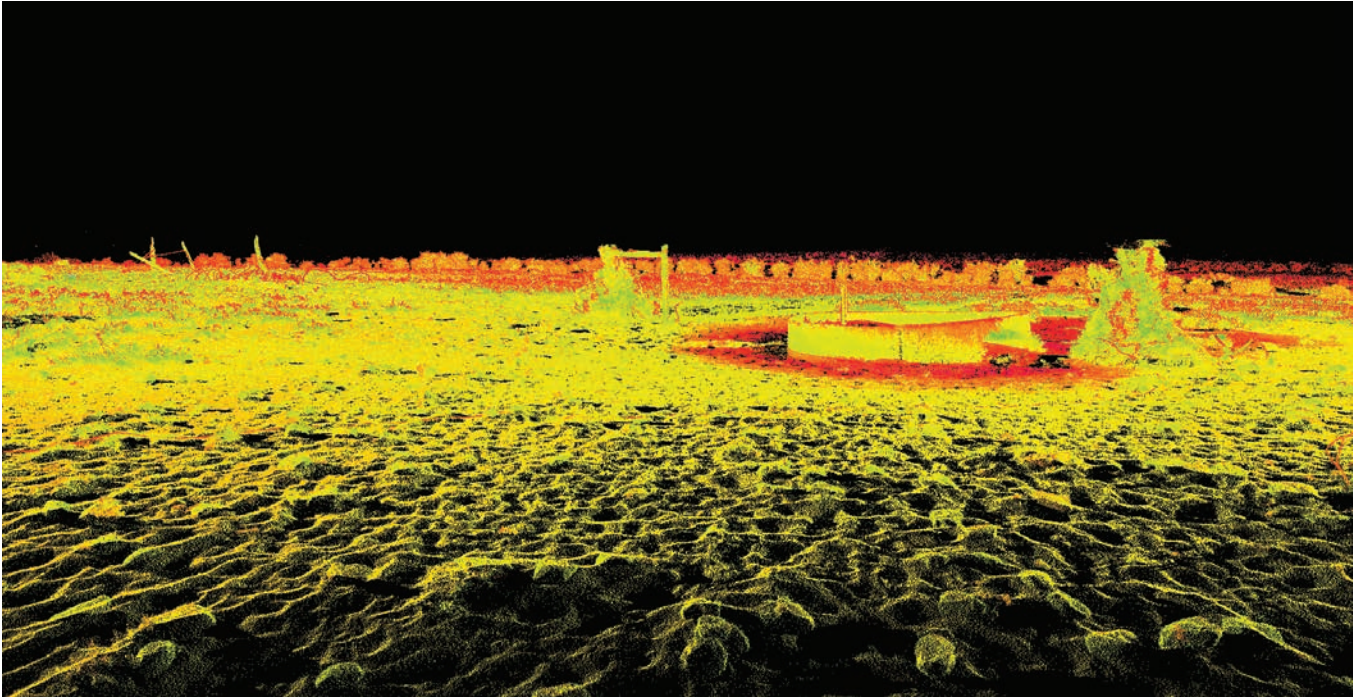


Intensity value scan data view of Pedro Trujillo corrals

Teofilo Trujillo Homestead

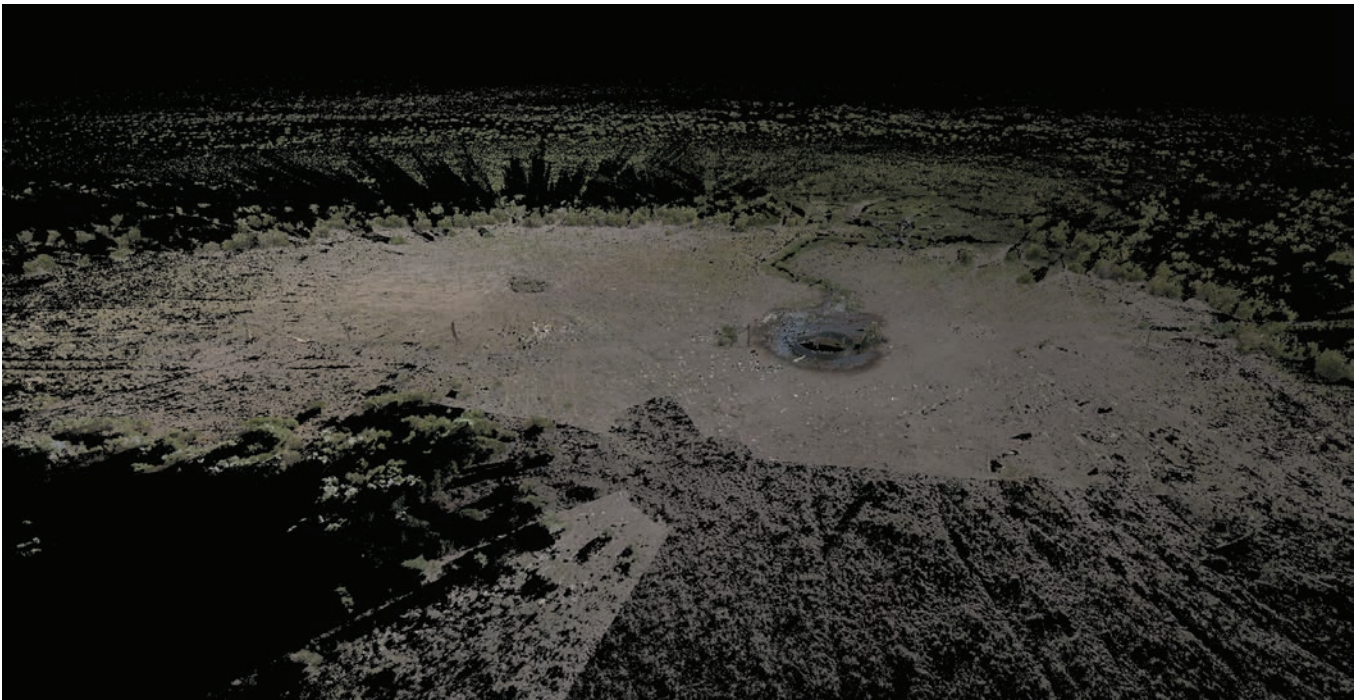


View of Teofilo Trujillo Homestead site



Intensity value scan data view of Teofilo Trujillo Homestead site

Teofilo Trujillo Homestead

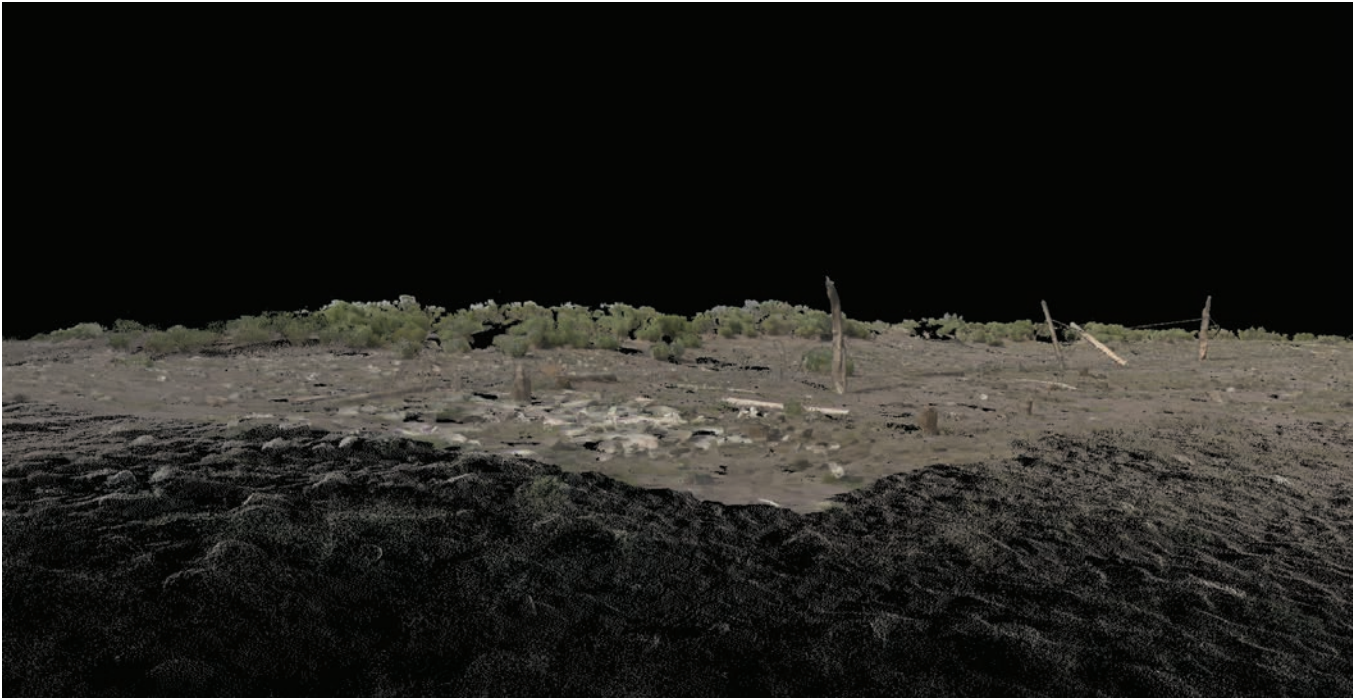


Aerial view of entire Teofilo Trujillo Homestead site

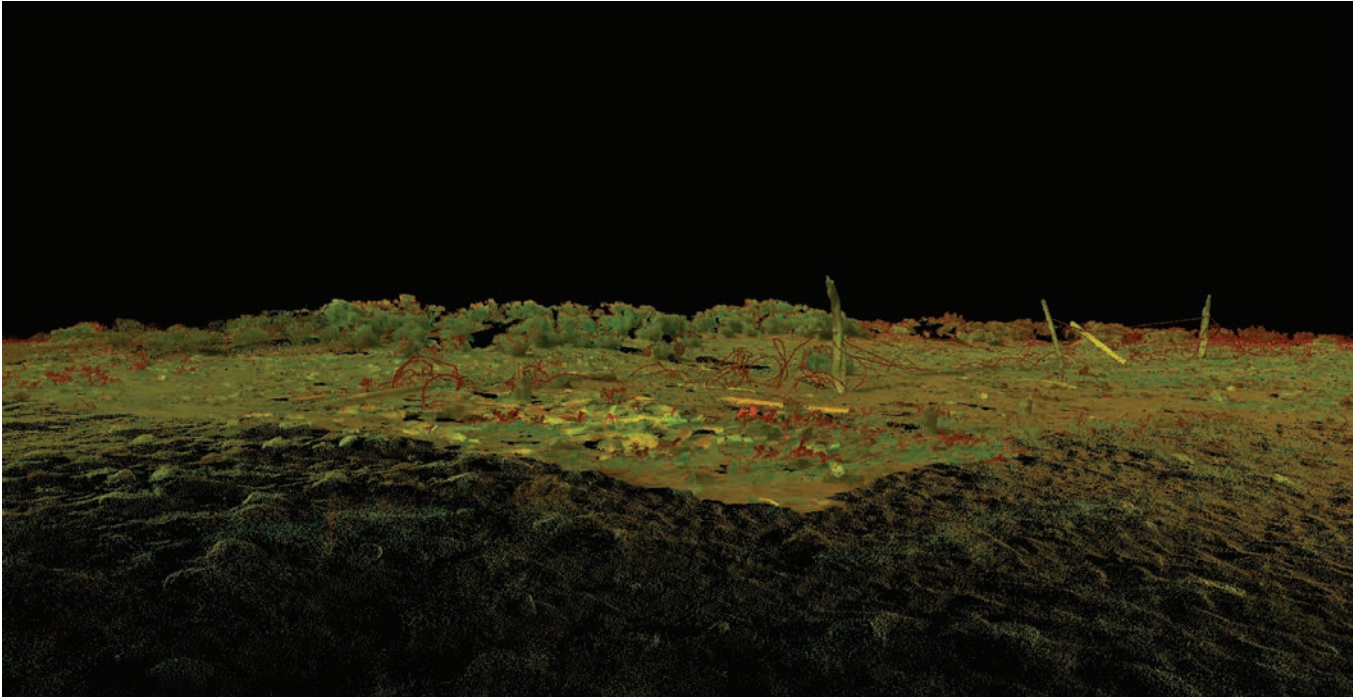


View of fence posts on Teofilo Trujillo Homestead site

Teofilo Trujillo Homestead



View of rubble pile with fence posts in background at Teofilo Trujillo Homestead site

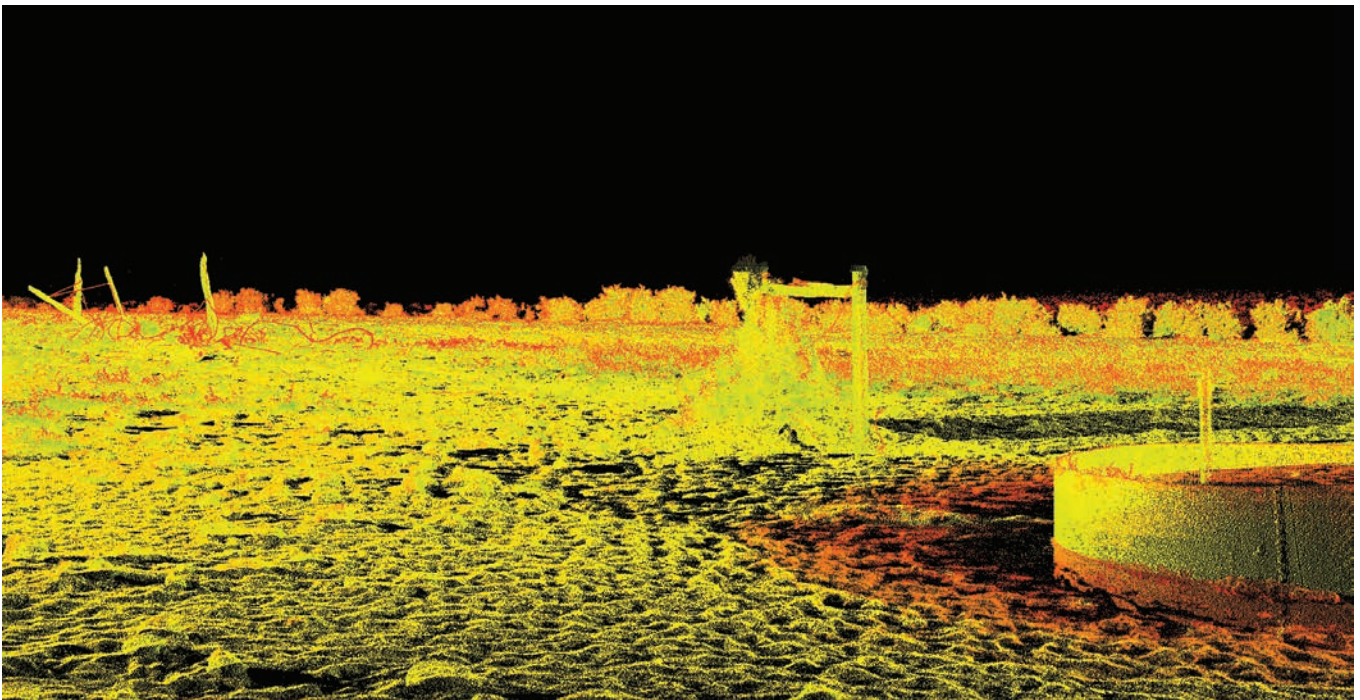


RGB and Intensity value scan data of rubble pile with fence posts in background at Teofilo Trujillo Homestead site

Teofilo Trujillo Homestead



View of watering trough with fence posts in background on the Teofilo Trujillo Homestead site



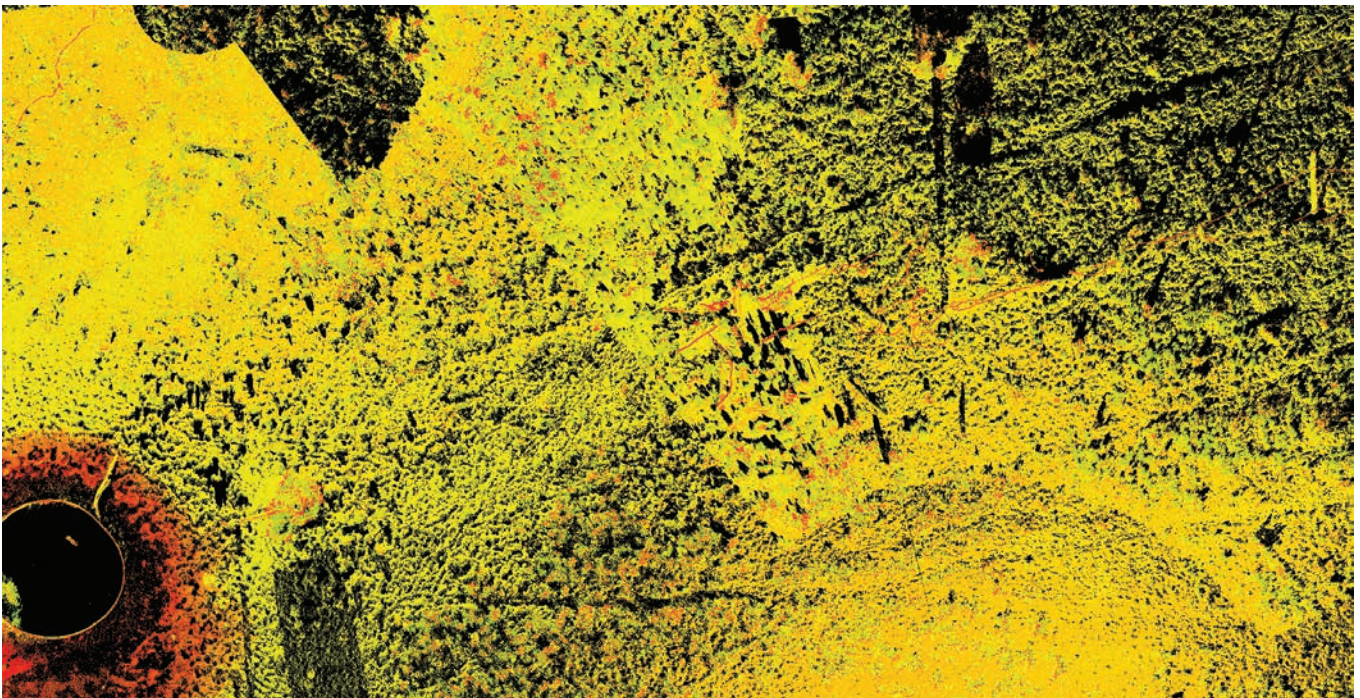
Intensity value scan data of watering trough with fence posts in background on the Teofilo Trujillo Homestead site



Teofilo Trujillo Homestead

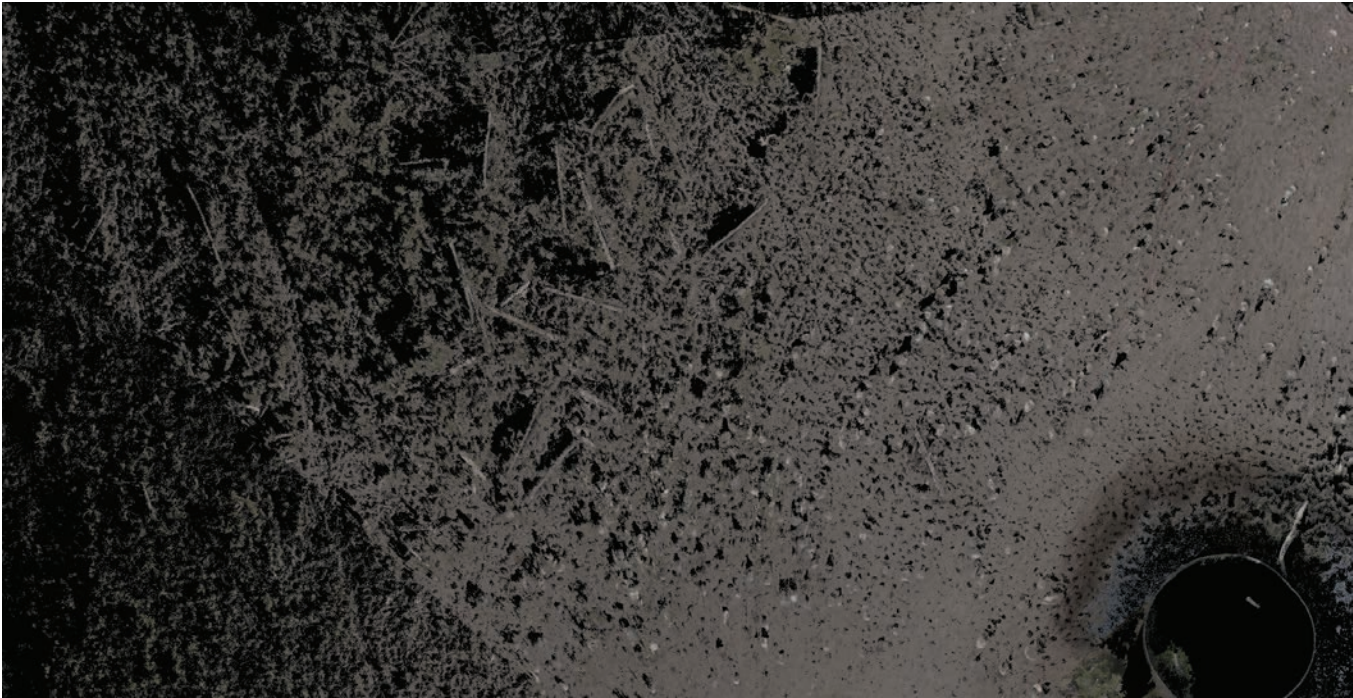


Orthogonal plan view of rubble pile near fence posts on the Teofilo Trujillo Homestead site

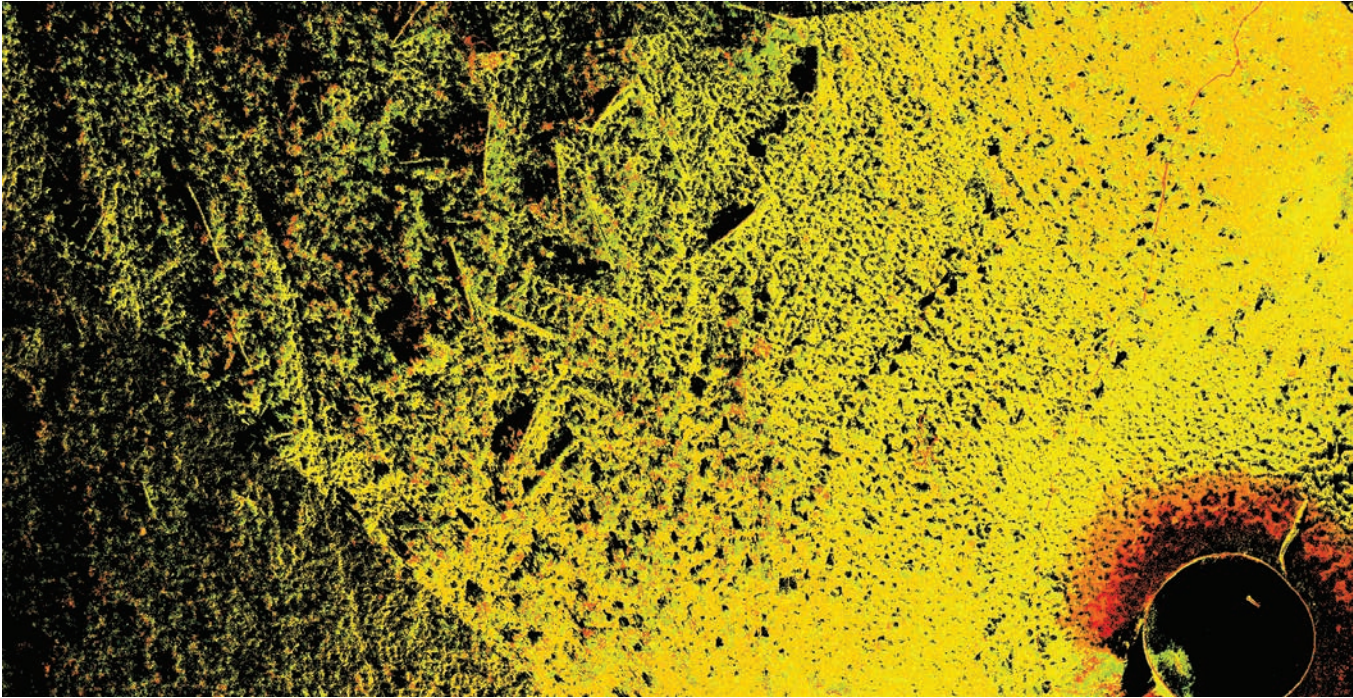


Intensity value scan data orthogonal plan view of rubble pile near fence posts on the Teofilo Trujillo Homestead site

Teofilo Trujillo Homestead



Orthogonal plan view of rubble pile to the Northwest of water trough



Intensity value scan data orthogonal plan view of rubble pile to the Northwest of water trough

The University of Colorado Denver, College of Architecture and Planning, Center of Preservation Research

Digital Documentation Field Record



PROJECT NAME: PEDRO TRUJILLO

DATE: 6.19.2012 - 6.20.2012 - 6.21.2012

6.19.2012
w High of 91°, sunny, calm winds
6.19.2012
High of 92°, sunny, calm
6.20.2012
High of 88°, sunny

Station:	Comments / Notes:	Pano Folder Name:	Scanner ID:	Scanner Height (m):	Scan Resolution (Xmm @ Xm):	Target IDs:	Target Types:	Target Heights (m):
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02	Window scan	PPT02	1	"	4mm @ 20m	7, 5, 6, 3, 4	"	"
03	360° scan ~ 55 min.	PPT03	"	"	5mm @ 15m	NONE (flashed)	"	"
04	360° scan ~ 55 min.	PPT04	"	"	5mm @ 15m	3, 5, 6 (fine scan)	"	"
05	Window scan	PPT05	"	"	5mm @ 20m	5, 6, 7, 3	"	"
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SS06	6.20.2012 Window scan, 17 min	PPT06	"	"	5mm @ 20m	1, 2, 5, 6, 7 Excluded	"	"
07	Window scan, 12 min	PPT07	"	"	5mm @ 20m	2, 6, 7 Fine scan	"	"
08	360° scan ~ 72 min.	PPT08	"	"	5mm @ 15m	1, 2, 3, 4, 5, 6, 7 Fine scan	"	"
09	Window scan, 25 min.	PPT09	1	"	5mm @ 15m	5, 6, 7 Fine scan	"	"
10	Window scan, 15 min	PPT10	"	"	5mm @ 20m	1, 2, 5, 6, 7	"	"
<hr/>								
SS11	6.21.2012 Window scan, 18 min	PPT11	"	"	5mm @ 10m	NONE, FLASH w/ SS 07	"	"





Panorama Post-Processing Notes



Pedro Trujillo Registration Map

