

Rediscovering a Hidden City: Exploring Vulci through Remote Sensing



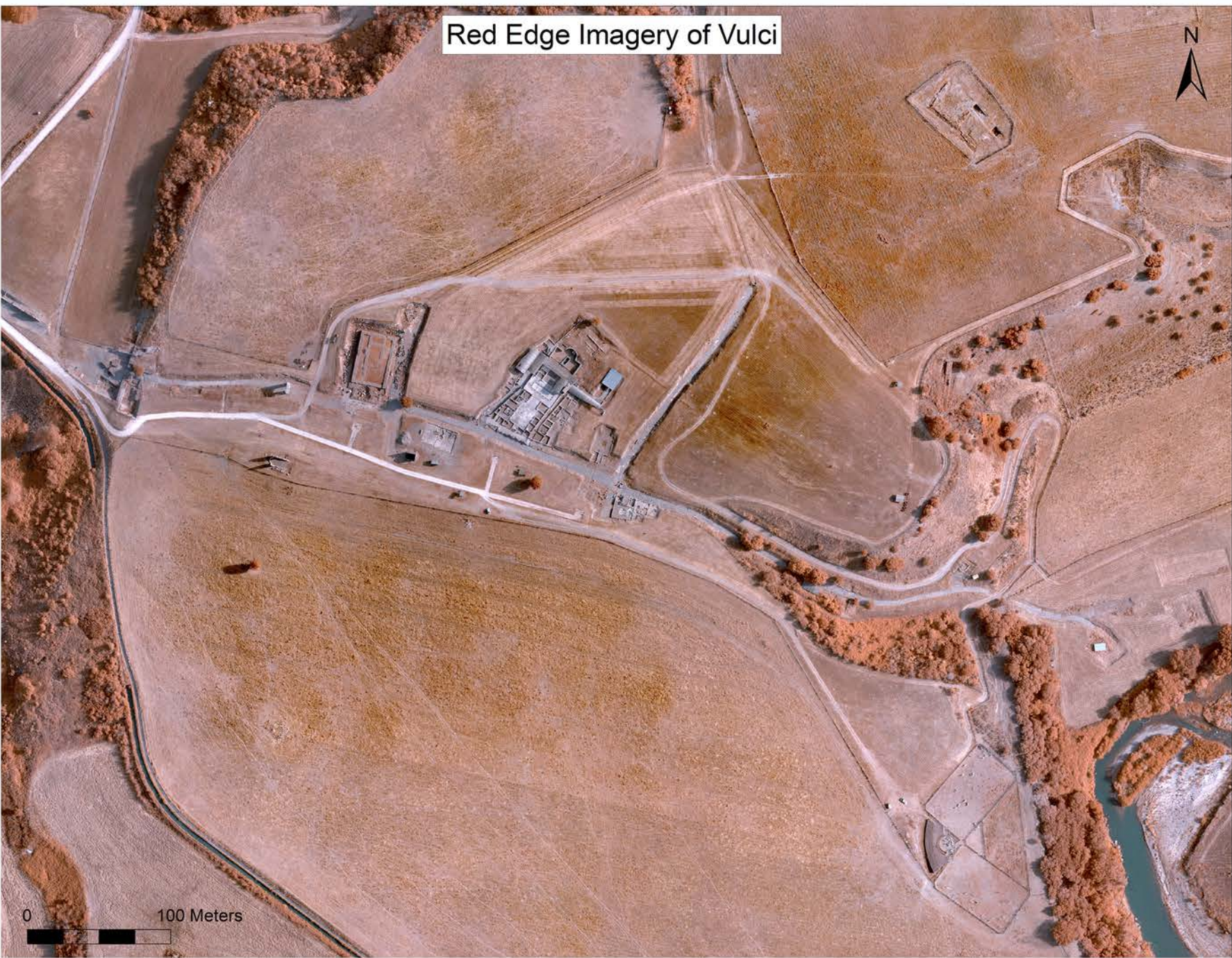
Introduction

This project focuses on using remote sensing techniques to map out and analyze the Etruscan-Roman city of Vulci, Italy. This flourishing city was home to a vast population for hundreds of years, yet much of the city proper remains hidden. This project demonstrates the effectiveness of these digital techniques to analyze the urban morphology of Vulci.

The analysis and conclusions presented here form a crucial part of the digital analysis section of my dissertation, as well as the Vulci3000 project. The project seeks to study the transformation and transition of Vulci from the earliest period (Etruscan) to the Roman occupation and the late antiquity.

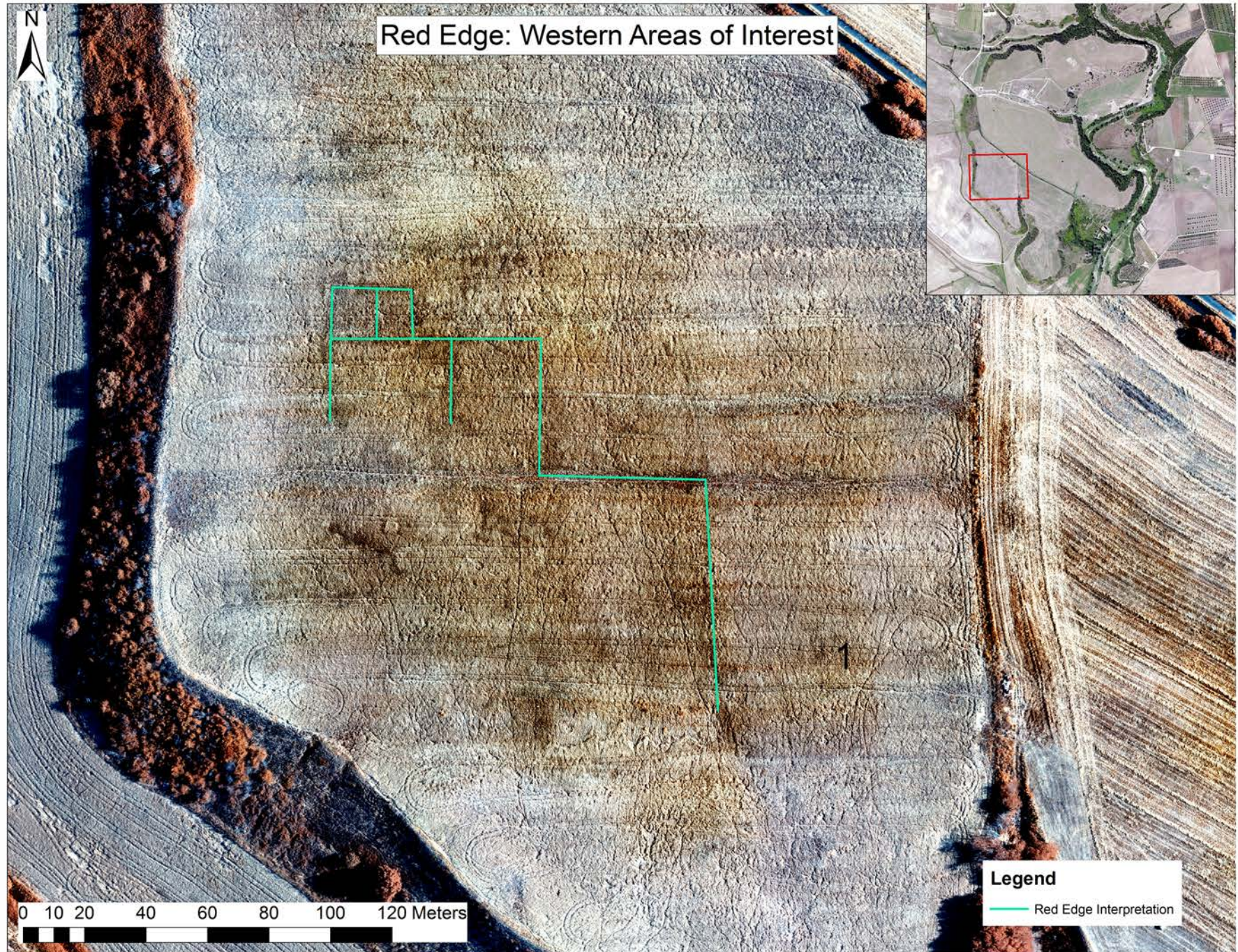


Vulci is located in what was the southern part of Etruria, which is today about an hour north of Rome.



The map on the left is the combined aerial images taken with a red edge camera. This band was the most successful in revealing underground features.

This close up view of stretched red edge imagery reveal shifts in soil and vegetation as the darker color reveals subterranean features. A possible large multi-roomed building can be seen here.



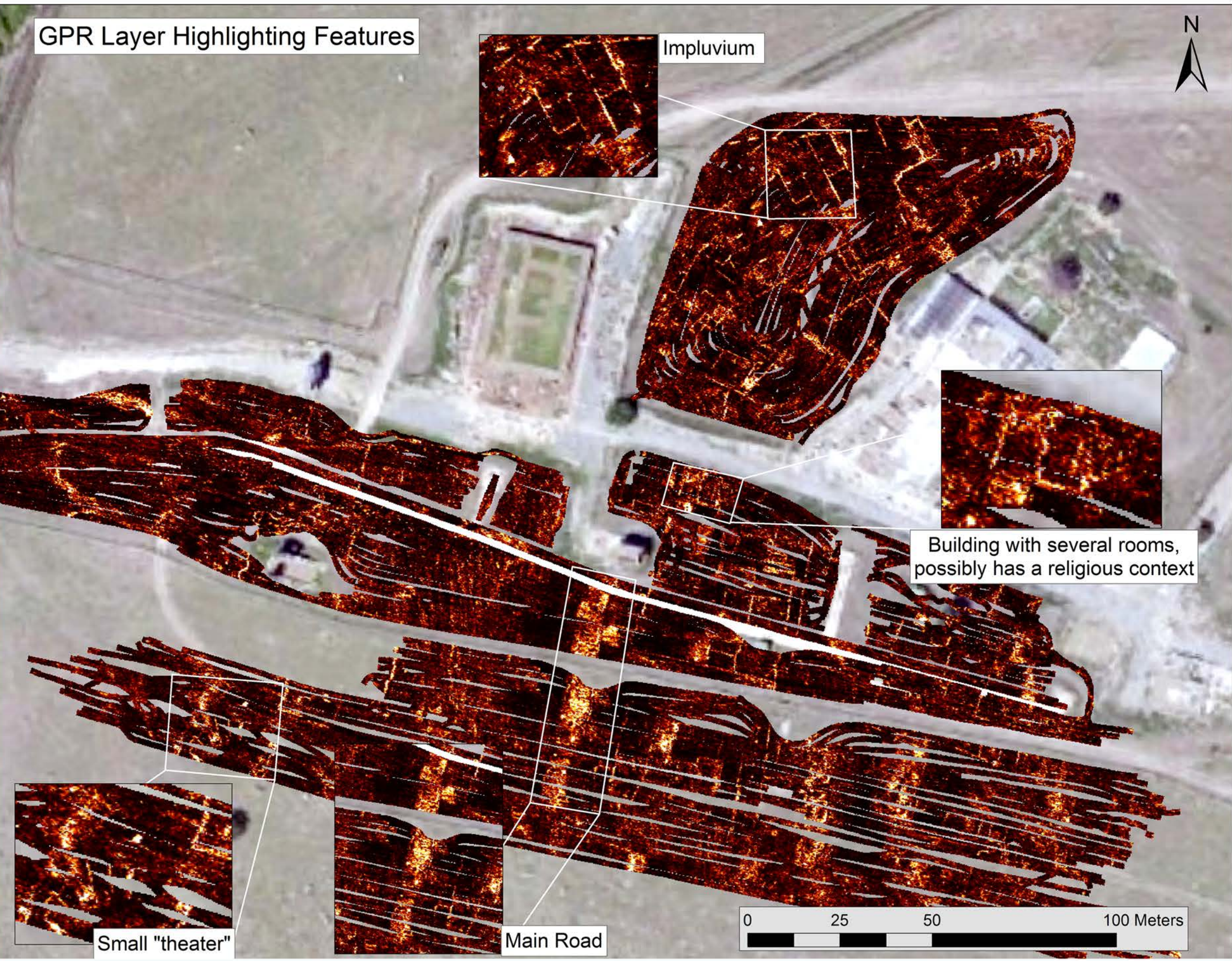
Challenges of a Traditional Approach

Although Vulci is now a protected archaeological park, it is too large and would be too expensive and time consuming to excavate the whole plateau. Unable to excavate the entire city, we therefore approached the problem from a different angle by using remote sensing techniques. This allowed us to piece together a more complex and nuanced understanding of the urban center in a holistic manner.



A procedural model of the city (left) was created from the data collected thus far. Using an online platform, we are able to spatially visualize the city in 3D and adapt it to new data.

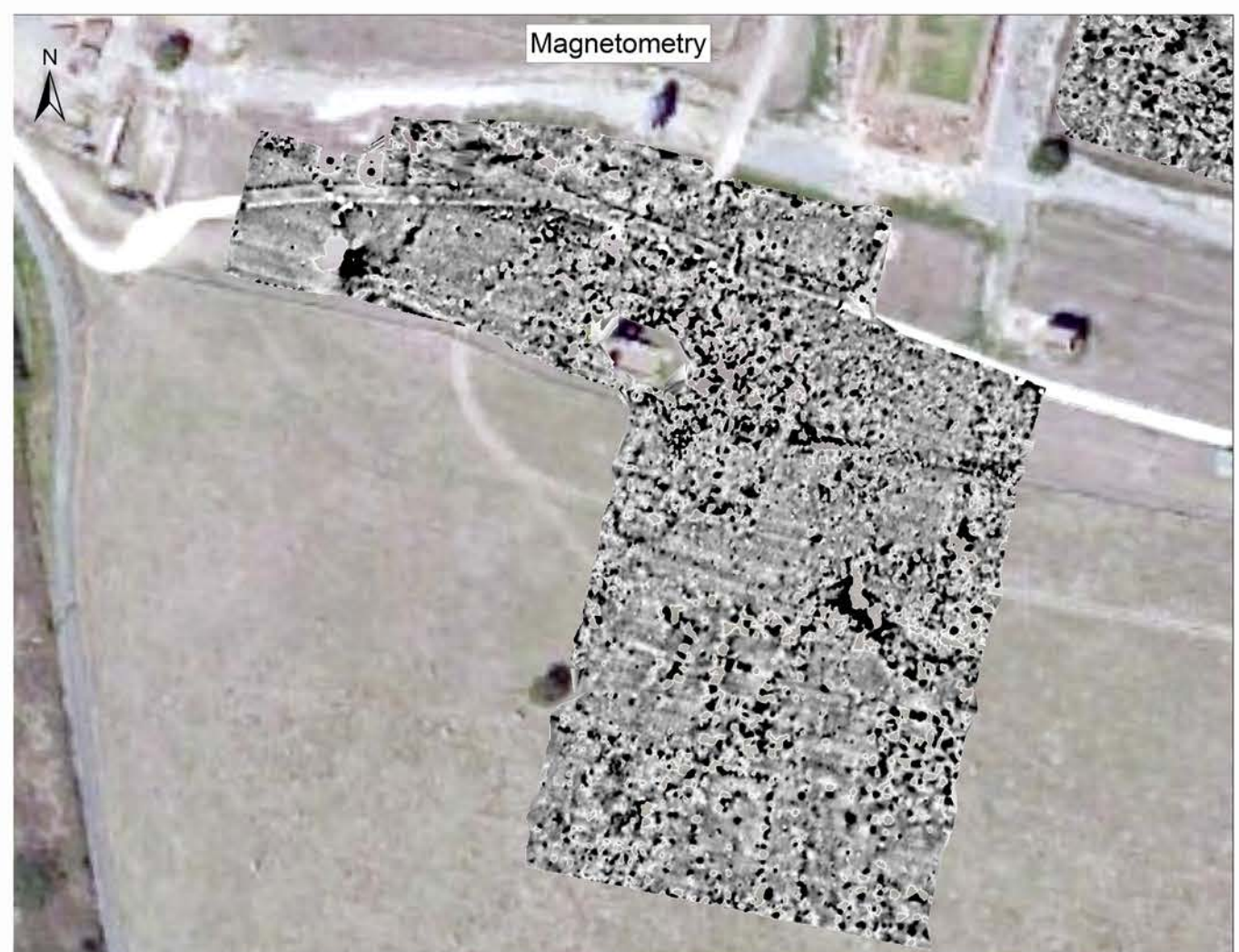
The map below shows several features discovered by analyzing the ground penetrating radar data.



Methods

This project combines various remote sensing data as well as procedural modeling for a layered analysis, which provides a holistic interpretation. From 2014 through 2016, we have collected data from magnetometry, ground penetrating radar (GPR), and aerial photography from two separate drones using four different cameras.

While a magnetometry survey of four areas was carried out during the summer of 2014, it produced patterns that were relatively indistinct and inconclusive. Thus, we moved to a different type of remote sensing technique, ground penetrating radar.



Inconclusive magnetometry results

Ground Penetrating Radar

Ground Penetrating Radar, or GPR, is a remote sensing technique that uses radar pulses to construct an image of subsurface features. Our team conducted a GPR survey of four hectares centered on the main western forum of the city during the summer of 2015.

Analysis of the GPR layers reveal several new features, offering a more holistic view of both the public and private buildings in the western forum and southern area of the site. Further, from this data, it is clear that the layout of the western forum and southern area remained constant throughout several periods. These findings also substantiate previous claims.

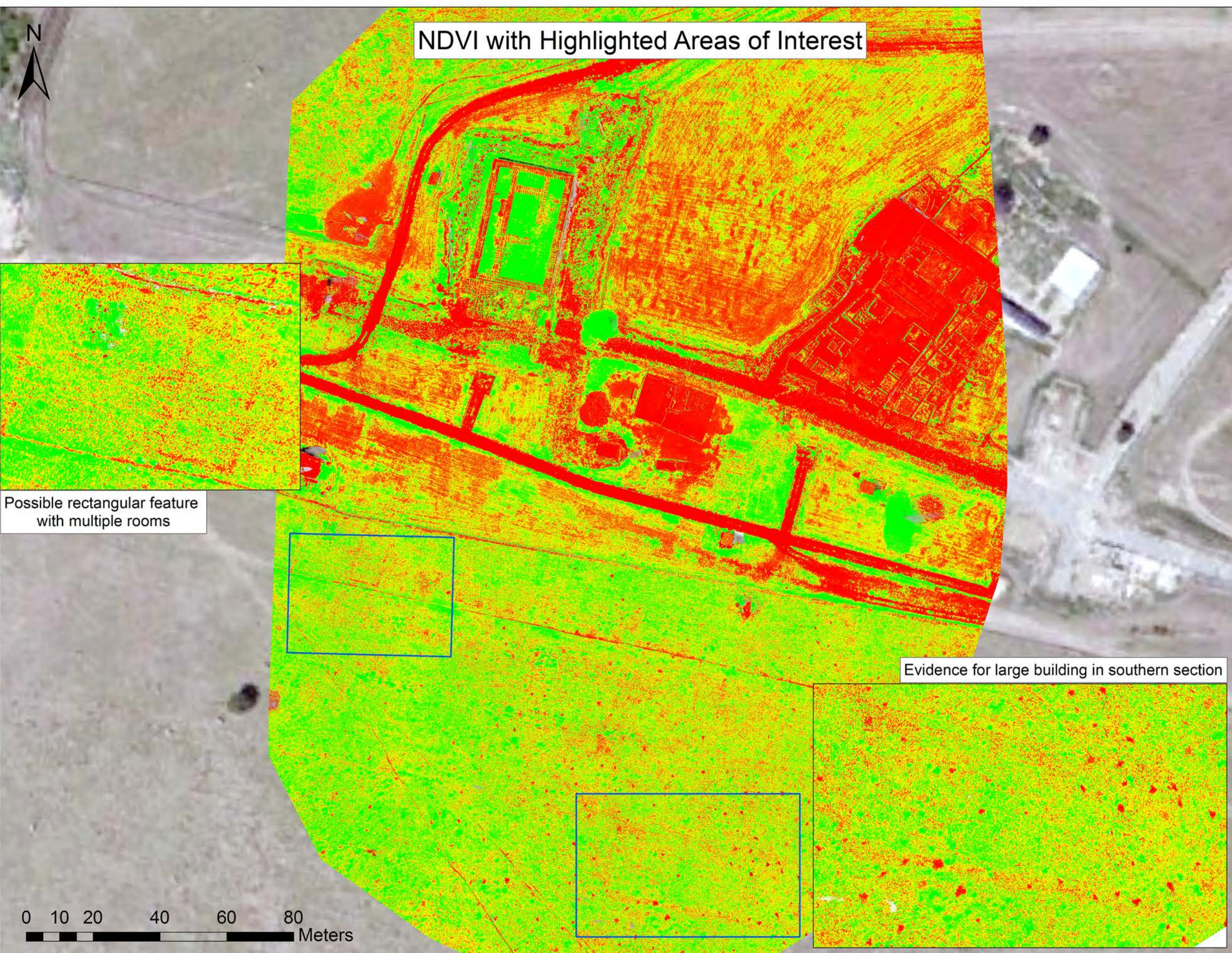
Aerial Photography using Drones

Despite the necessity of both the LiDAR information and old aerial photographs, high quality data was required for a more in-depth and complete analysis. Therefore, we flew a fully automated drone from SenesFly (eBee) over the entire Vulci settlement.

Aerial photographs of the entire park were collected using colored (RGB), near infrared (NIR), and red edge (RE) high quality sensors. An initial processing of this data provided a high quality NDVI (Normalized Difference Vegetation Index) image focusing on the Western Forum. The NDVI elaboration was used in order to identify miniscule traces of submerged masonry structures otherwise invisible in RGB and aerial photos.

$$NDVI = \frac{RED_R - RED_{VS}}{RED_R + RED_{VS}} = \begin{cases} < 0 & \text{water} \\ \approx 0 & \text{soil} \\ > 0.4 - 0.8 & \text{vegetation} \end{cases}$$

The success of this process prompts further aerial photography with a multi-spectral camera this summer.



This NDVI supplements the other aerial imagery and GPR data to show a large building in the lower right of the data as well as several other additional features.

Conclusions and Further Research

- There is evidence to support the reuse of the street grid and urban layout by subsequent occupants
- The combination of different bands from aerial photographs reveals the presence of several large buildings south of the main Western Forum, as well as an expansion of smaller features south.
- Further analysis is needed in the northern sector of the site to determine spatial patterns
- While the data covers the urban center of the city, the boundary between the city and the rural area needs to be more clearly defined.

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