Understanding the Villa di Tito and the Velino Valley within Central Italy by Creating Spatial Connections

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This research aims to understand the placement of the Villa di Tito (Villa of Titus) located in the central Apennines in the territory historically known as the Sabine Territory. This research applies ArcGIS Pro and is divided into two forms of analysis. The first compares the Villa di Tito to sample villas located within the Sabine region, using environmental (including slope, elevation, aspect, geology, rivers, lakes, and solar radiation) and cultural (including Roman roads, and archaeological sites) datasets. The aim is to see whether a pattern can be found for villas based on the placement and potential for agropastoral production. In addition, ancient agronomists' farming manuals such as Cato, Columella, Varro and Pliny were incorporated to understand a villa's placement in the landscape. The second form of analysis examined the connectivity of the Villa di Tito to other archaeological sites within the Sabine Region by applying optimal path analysis. Combined, these two analyses aim to understand the placement of the Villa di Tito in the Velino Valley and its connection to the broader landscape. The Villa di Tito was found to be a unique placement based on the comparison villas and was well connected with the broader Sabine region.

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Chapter 1: Introduction and Literature Review

1.1 Introduction

This research aims to compare Roman villas in a lesser-known part of the Sabine Territory of central Italy, which falls within the modern provinces of Lazio, Umbria and Abruzzo. The research applies spatial connections through the application of ArcGIS Pro. These connections will be in proximity to cultural places and natural landscape characteristics. This thesis includes two types of analyses. The first analysis reviews the characteristics of a sample of twenty-four villas found in the Sabine Territory which includes the Villa di Tito. Based on this comparison, the aim is to determine whether the villas in the territory were constructed within similar parts of the natural landscape. The second analysis creates optimal paths and explores the connections between the Villa di Tito and other contemporary archaeological sites in central Italy to the east of the Tiber River.

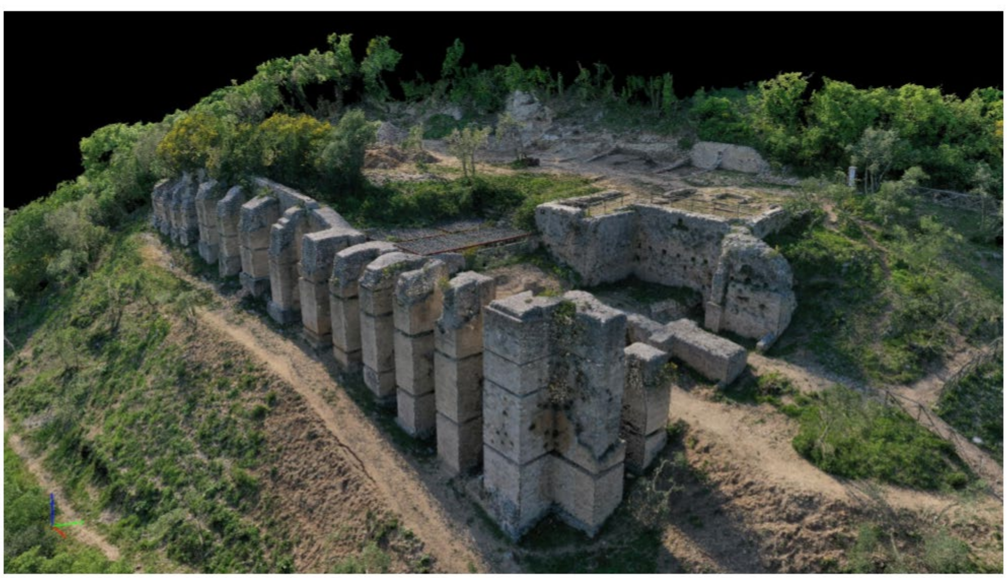

Figure 1.1: 3D image of the Villa di Tito created by Greg Baker, Maritime Provinces Spatial Analysis Research Unit, Saint Mary's University in 2019.

Four types of inquiries were applied: villa archaeology, settlement archaeology, landscape archaeology and Geographic Information Systems (GIS) within archaeology. Roman villas are a well studied type of archaeological site, although the interpretative framework has changed over the decades to relate to the research interests of archaeologists and historians. Settlement archaeology examines the diachronic development of settlement types and settlement hierarchies. Settlement archaeology closely overlaps with landscape archaeology. Landscape archaeology is a theoretical framework that approaches how the landscape impacted humans or how humans manipulated the landscape. This is an important practice because it applies a newer approach developed during the post processual phase in archaeology (est. 1990s-present). Lastly GIS is a technological tool that has been most frequently applied in landscape archaeology. It allows archaeologists to study the spatial context of one or more archaeological sites and use spatial tools to examine connections within the sites to analyze the physical characteristics of a site (or multiple sites) that are related to the physical setting.

1.2 Literature Review

1.2.1 Villa Archaeology

Villa archaeology is a broad topic of interest in relation to the Roman Empire. There is a variability of settlement types, with both rural and urban examples, and with regional variations across Italy and the Roman Empire. There were also distinct types of villas during discrete historical periods, including the Roman Republican, Imperial and Late Antique periods. There are several functional categories for villas created by researchers and historians over the past decades. The three main categories are rustic, suburban, and maritime (McKay, 1975), which are based on geographic location and economic function. Maritime villas were located along the coast whereas suburban villas were in or near a city, and rustic villas were in the countryside. The economic function varies with the location of the villa. Some of these economic ventures associated with villas include fish farming and agricultural production (Marzano, 2007). Villas were an important feature within rural settlements in ancient Italy. The sites were used for commercial exploitation of the countryside, which could include the production of agricultural, pastoral and forestry products that would then be sold at market. The initial evidence that would evolve into the villa prototype specifically within the territory of ancient Taras or Tarentum were found to be structures used to fortify settlements created by the elite in the 5th and 6th centuries B.C.E (Torelli, 2012). Survey archaeologists often categorize villas as farmsteads within local or regional site hierarchies, with villas being the largest and most prominent such sites (Witcher, 2006).

Villas were also a place of leisure and the ideal location for landowning social elites to engage in *otium*, which was the practice of owners participating in productive exercises of the mind (Marzano and Métraux, 2018). Villas were also residences, and this was also studied apart from the economic ventures a villa would participate in. The analysis considers the rooms as a space and seeks to learn how individuals chose what to do with them. The attribution of domestic spaces by Romans are based on the room's location in the house and the décor being used (Clarke, 1991). An example of this can be seen in Pompeian houses. Wallace-Hadrill (1994) wrote a book on understanding the household as a social space by looking at the private and public spheres within Pompeian houses and how spaces functioned within a given household.

The rustic villa type is the focus of my thesis. Rustic villas are a subtype of villa which are located outside of a city. Marzano (2007) describes the terminology of a rustic villa as a specific moniker because it focuses on villas located inland compared to maritime villas that are found by the coast. During the Roman period, the number of villas increased within Italy over time, especially during the 1st century C.E. The rustic villa was a key type in rural settings with surplus production being its main purpose. Villas were establishment outside the city that were dedicated to agricultural production intended for market exchange (Marzano, 2007). The products for exchange were often used by the villa owners to generate revenue for the purposes of maintaining their urban lifestyle and political life. (Marzano and Métraux, 2018).

Another characteristic used to classify villa properties were imperial and senatorial owned villas. Imperial villas owned by emperors often influenced the economic sphere. Depending on the villa, many just became a place of production instead of a place of leisure for the owner. Villa owners of a very high socio-economic statues could own multiple villa properties, both in Italy as well as Rome's provinces. An example of someone with multiple villa ownership is the author and magistrate Pliny the Younger. Within the *Epistulae* he often refers to the production or leisure activities he participated in from both his Laurentine Villa (1.9; 2.17) and his Tuscan villa (5.6; 10.36; 10.40).

Imperial and senatorial estates were close to urban markets for agricultural products and are sometimes viewed as being a direct response to the demands of the market (Lo Cascio, 2018). The imperial estates influence the market because the revenue was spent on public purpose instead of whomever owns the villa. This would include supporting the imperial family, imperial bureaucracy, the military and public buildings (McCallum, 2021).

A form of villa analysis is searching for who owned the property. Di Giuseppe (2014) studied the ownership of imperial properties in southern Italy from the Julio Claudian to the Antonine period. Her work is a good example of how imperial ownership can be identified using epigraphic evidence. Through excavating the villa many personal connections can be made through inscriptions being in situ and other inscribed artifacts around the region helped connect individuals to the site, therefore, building a reconstruction of ownership. Relating this idea to the

Villa di Tito there has been interest on who owned the villa. Ownership is often attributed to the Flavian dynasty (and named after the emperor Titus) but there has yet to be archaeological evidence found to connect the site to this family.

Rustic villas were most frequently valued within the economic sphere through their participation in agropastoralism. Agriculture practiced on a Roman villa usually focused on farming with typical crops being grains, grapes, olives, fruits, and legumes. These items were typically processed onsite, and the remains of pressing facilities used in production of wine and oil have been identified by Rossiter (1981) in villas throughout Italy. Examples include the Villa at San Giusto in Puglia, where a *cella vinaria* (wine storage area), dolia for aging wine, a *calcatorium* (a wine press) and a *lacus vinarius*, (a basin for stomping grapes and starting fermentation) were identified (Soren, 2000; Volpe, 1998). Another example, this time within the Sabine Territory, comes from the excavations of the Villa at Vacone where a press for olive and later wine production was found (Franconi et. al., 2019). Another characteristic of villa living was pastoralism, which is noted by Roman Agronomists like Varro and Columella. The main Roman farm animals were cattle, sheep, pigs, donkeys, horses and chickens. These animals provided meat, wool, hides, milk, eggs, manure, transportation and traction (Hollander, 2019).

For rustic villas, there was a hierarchy of agricultural sites in the countryside due to the transition from smaller to larger farmsteads because it had fertile lands and was in proximity to the Roman market (Coarelli, 2009). Villas were an important feature within the Roman world because they influenced the economic, traditional, and cultural sphere within Italy as well as the rest of the empire. They were a symbol of wealth in relation to the imperial families and influenced the surrounding areas where they were located. With the periods of use, villa archaeology helped with the interpretation of rural areas, construction of households, the economic production and the social classes involved with villas. By the late 5th century C.E the use of villas declined in the Western Roman Empire, they ceased to be a symbol for the elite and these monumental buildings fell into disuse (Bowes, 2007).

1.2.2 Settlement Archaeology in Italy

Presenting the settlement periods can help show how there are many factors to consider in order to understand the function of the landscape. There are many influences to consider when trying to understand a specific period. Settlement archaeology is the diachronic study of past settlement patterns within a specific geographical region or territory. This thesis looks at settlement patterns in central Italy in the central Apennines during the Roman Period (*ca.* 500 B.C.E-400 C. E), focusing on the 1st- 2nd centuries C.E. A common format for interpreting sites is to display the information of the site (and its evidence) by framing it through the historical periods beginning at the Iron Age to the Middle Ages.

The current model of diachronic settlement patterns is based primarily on survey data from different field projects, despite some of the datasets being difficult to compare due to different research objectives and methods (Witcher, 2006). These surveys are then interconnected with the excavation datasets for sites as well. In the central Italian countryside, village settlements arose in the Iron Age and were constructed on hilltops. By the end of the Iron Age there was a shift in settlement patterns which were established in the Italian peninsula and during Roman expansion. Roman expansion was a significant catalyst for changes in rural settlements throughout central Italy. The change in the countryside was not as uniform but depended on each settlement and Roman colonization (Bradley, 2000). Some settlements already had a connection to Rome prior to Roman expansion whereas others did not. More generally, the kinds of relationships that were being developed and fostered at the time were embedded in the long-term evolution of a system of social dependencies that had been in place since the early first millennium B.C.E. As in many other areas, the new process can be seen as a scaled-up version of a traditional cultural element (Terrenato, 2019). An example of this is Rome's absorption and appropriation of elements of Etruscan culture during its expansion within Italy. Through the assimilation of the Etruscan aristocracy, it rearranged the socio-economic structures of the area in relation to both Rome and Etruria (Torelli, 2009). During the Roman period, settlements shifted into becoming urban centres in the lowlands and were near major travel routes (Barker, 1998). Within the Empire the rural countryside developed a form of hierarchy in which the urban centres and villas became central to the countryside.

By the Late Antique period settlements in Italy went through another transition, which was the abandonment of urban settlements and the reorganization of those still occupied. Within rural Italy villages arose and were organized by a smaller administration. There are three common models used to show the changes in rural settlement after the Roman period for villas. Archaeologically, some villas after the Roman period were still used as residences, while others were used as cemeteries or as centers of production only (Dodd, 2021). Some villas were converted into Christian churches while medieval villages developed around others (Munro, 2010). For example, there are many examples of Christian churches built on ruins of Roman rural sanctuaries and villas, such as *Santa Maria in Cesonis* on the Baths of Vespasian (Trizio, 2019), a church built on the remains of the Villa Magna (Fentress, 2016), San Vincenzo al Volturno (Hodges, 1997) and San Giusto (Volpe, 1998). Villa Magna and San Vincenzo al Volturno also came to be surrounded by agricultural villages. Some examples of social and political factors that changed the landscape were the influence of Christian churches and how the political authority on the peninsula went from one political entity to multiple entities. Most researchers agree that

"that major changes occurred and are broadly known after AD 400- late Roman political and economic decay, insecurity, barbarian takeovers or integration Christianisation, changing burial traditions, technological losses, diverse settlement forms, village growth, castles, monastic spread, etc." (Christie 2016, p. 84). These became a new form of central organization instead of the past Roman centres and villas. Another consequence of these changes was the rebuilding and reoccupation of Roman sites in the form of villages, churches and cemeteries to the Early Middle Ages.

1.2.3 Landscape Archaeology

Landscape archaeology focuses on the relationship between humans and the landscape in the past. There is a particular interest in how the landscape was formed and how human activities may have been shaped by the landscape. Anshcutetz et al. (2001) includes four significant paradigms to apply to the study of landscape archaeology: landscapes are synthetic with cultural systems and organizing people's interactions; landscapes are a cultural product that can change into something meaningful; landscapes are a place for community activities; and landscapes are dynamic constructions which change in each generation.[1] In landscape archaeology the combination of the natural influences of the landscape, climate and human activities provides a holistic approach to interpret the past. Landscape archaeology does not have a clear methodology and is dependant on multiple factors like research strategy, material culture, and landscape evolution for a project to render useful results (Christie, 2016).

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[1] Anshcutetz et al. lists the four features as landscape paradigms including a definition for each and additional citations of authors related to each one. For a more detailed read the paradigms can be found on page 160-161.

Technological evidence like aerial photography, field survey, geophysics, and mapping tools are used to help further understand sites and historic landscape (Keay et al., 2014). The technical approaches and evidence can show whether landscape changes were caused by natural factors or were a part of anthropogenic change. Pollen core samples are analyzed to show new plant growth in an area or the abrupt disuse of certain plants (Mensing et al., 2018). Various analyses can be applied to understand the landscape; one example of an application for the interpretation of paleoclimate is stable isotope geochemistry of authigenic carbonate in lake sediment. Authigenic carbonate enriches the lake water and through preferential evaporation, therefore, a higher carbonate value represents a hotter/ drier climate in the summer (Dingemans, 2019). Also, more data from a wider spatial network with good chronological control is essential to overcome any contradictions and uncertainties when describing Roman climate (Manning, 2013).

Other processes that include interdisciplinary works are the creation of 3D models that can show estimations about how a basin was infilled (Chiarini et al., 2014). Landscape archaeology incorporates multiple scientific factors to further the analysis of archaeological sites and can give predictions that further the historical context of an area. In general, there is also a need for landscape archaeology to bridge the literature of what the environment was like and how to experience it, which allows both the scientific and interpretive work needed in landscape analysis (Johnson, 2012). Having an interdisciplinary emphasis on features is needed because it is key to the methods used throughout this thesis. In this thesis, the tools needed to understand the Roman period require both historical information of the landscape and the application of contemporary datasets to express the connectivity of the Villa di Tito to other archaeological sites in the Sabine Territory.

1.2.4 GIS and its applications in Archaeology

Geographic Information Systems (GIS) is a program whose geoprocessing tools can be applied to the study of archaeological sites. In general, GIS can facilitate spatial analysis, creating networks in the landscape, and generating 3D models. Within this thesis the main use of ArcGIS Pro is on spatial analysis and creating networks. GIS can be used to show potential pathways that connect sites within specific historical periods (Llobera, 2011). Also, the application of spatial statistics, principles of geography, and the various methods that can help with spatial patterning and the spatial relationship between archaeological sites is important for contextual data (Jones, 2017). In turn, it can provide an analysis of how agricultural production directly affects settlement distribution, demography, urbanization, and economy (De Haas, 2017; Goodchild, 2013). The frequent practice of evaluating datasets on a site would be the application of spatial and prediction analysis. When using prediction analysis, a model can be used on a smaller area to show a predictive model to visualize potential places that were useful for production and apply features that are considered important for the area (Trapero-Fernández, 2016). For the purpose of such an analysis a study area is picked and a list or variables (ex. waterways, soil types, slope, sunlight) are weighted to predict what area would be best for production purposes. Reviewing the settlement patterns is another application of GIS spatial analysis. Viewshed analysis can provide visuals to the researchers showing the elements of agriculture in settlements which can help show productive lands, water, and proximity to resources for building and fuel (Sevenant and Antrop, 2007).

Least Cost Paths is a type of analysis that provides another way of applying spatial connections. Least cost paths are used under the assumption that people are rational actors who try to reduce travel and transportation costs by choosing optimal routes. By optimising the costs researchers often go a step further by providing conditions both of cultural and physical factors to minimize assumptions within the paths (Güimil-Farina et al., 2015). A physical factor described by Carreras et al. (2019) use ArcGIS Pro to show how certain slope gradients are needed when researching cost paths within mountainous terrains. Additionally, these least cost algorithms that are used for optimal paths can be created to show human movement in the past, for example looking at human movement and access to natural resources (Field et al., 2019). Another feature that often arises in the literature related to least cost paths is the measurement of people moving on the landscape. The movement of people would entail the speed of a person travelling and/or their mode of transportation (ex. Walking, riding a horse, using a wagon etc...). Pandolf et al. (1977) and Tobler (1993) have generated algorithms to help estimate the amount of energy needed to move across the terrain.

A critique that is often reviewed within GIS is environmental determinism. Environmental determinism is the study of using the environment to predetermine how a society would develop in a specific region. There are problems with this theory, so it is important while using GIS to incorporate a cultural component to interpret the past. A solution to environmental determinism is to incorporate both 3D visuals and GIS for interpretation but keep the focus on the human perception of a site and not only the interpretations the program produces (Rissetto-Richards, 2017). Another option for this is "to establish a data hierarchization structure that is flexible enough to be constantly updated. This was found to be the best option, since it provides a procedural methodology that can be used in subsequent implementations" (Rua 2009, p. 224).

Another action for GIS in archaeology is to preserve the materials and features found in a site. GIS helps provide a reliable source for storage of information within a database because of what it can store. Some examples of what can be stored in relation to archaeological sites are vector and raster datasets related to the site, 3D images, and georeferenced points. GIS provides accurate models, measurements, and information of a site that can be studied from a computer (Tsiafaki and Michailidou, 2015). GIS is a useful tool for archaeological field research to compare datasets from a single site to multiple sites. We can assess the results of spatial analyses against what we currently know from archaeological research (Jones, 2017). The application of GIS in archaeological interpretation helps to bring a more analytical perspective to the data and to help identify characteristics that may have been missed just from working on a single site.

1.3 Objectives and research questions

Despite decades of archaeological research and data from Roman villas there are still gaps present in the literature in the mountainous parts of the study area, as will be demonstrated, there is little or no on-going research on Roman villas, aside from the Villa di Tito. By focusing on the four themes previously noted, this thesis aims to answer two core research questions:

> *What environmental, economic, and cultural factors influence the Villa di Tito's placement within the Velino Valley?*

> *What are the travelling patterns and network connections of the Villa di Tito to other archaeological sites in in the Roman period?*

To understand the Villa di Tito's location within the landscape, it is necessary to compare its placement to other rustic villas throughout the Sabine Territory. The next approach reviews the connectivity of the Villa di Tito in which paths are made to sites contemporary with the Villa di Tito. This is completed by building paths to cities, towns and road stations found in the Sabine Territory. This analysis will focus on points that were present during the Roman period. Some of them predate the Roman Imperial period but this thesis will concentrate specifically be on their presence during the Roman Empire in the 1st century C. E.

Chapter 2: Study Area

2.1 Study Area

This chapter defines the history and geography of the Sabine Territory which encompasses the Rieti Basin and Velino Valley. Figure 2.1 shows the parameters of the study area and the natural features worth noting in the landscape. The geographical boundaries were derived from two sources: digitized maps taken from *Romans: From Village to Empire* (Boatwright et al., 2012) and the *Barrington Atlas of the Greek and Roman world* (Talbert and Bagnall, 2000). There is an emphasis on the archaeological sites, within the Lazio due to this province having publicly available datasets.

This chapter begins with the geography section and focuses on the geology, soils, climate and bodies of water in the area. After this, there will be a shift to the historical component of overall central Italy in relation to the Rieti Basin and Velino Valley. The historical component includes the excavation history of the Villa di Tito and a summary of the history of central Italy dating from the Roman era to the Early Middle Ages. Combining history and geography provides a holistic understanding the study area and the socio-political changes that are relevant for this research.

Figure 2.1: The map provides an outline (white) of the area of interest within the Apennines and was apart of the historical territory of the Sabines.

2.2 Geography

The Sabine Territory in central Italy is divided into two main geographical units. The first is Tiberine Sabina which is closer to the Tiber Basin with a hillier landscape. The second is the Interior Sabina where the landscape is more mountainous with patches of flat agriculturally productive intermontane valleys (Alvino, 2009; Coarelli, 2009).

Figure 2.2: This is the Velino Valley from the western direction. Image taken by Rebecca Payne in 2022.

The Apennines are a mountain range that run through the center of the Italian peninsula measuring about 1200 km from north to south. They are divided into three regions known as northern, central, and southern Apennines, respectively. The focus here is on the central Apennines, wherein lies the Sabine territory. Within the Apennine mountains, the Villa di Tito rests on the lower slopes of Cimata di Castello, which is a lower peak of Monte Terminillo.[2] At 2217 m.a.s.l, Monte Terminillo, is one of the higher peaks in the Apennines. It is situated east

[2] Mountain names were collected from Mapcarta at this URL: https://mapcarta.com/N2485376631.

and south of the Velino River, which skirts its base, and west of the Rieti Basin (Piacentini et al., 2017).

The Velino Valley is located to the east of the Rieti Basin and the flatter terrain measures ca. 20km in length. The Via Salaria passes through this valley, which connected Ancient Rome to the Adriatic through the Apennines. The Velino Valley is a thrust ridge and contains a fault line that is influenced by its geomorphic evolution (Piacentini et al., 2017). Much of Rieti and Velino area are like the central Apennines which filled with sediment build up in the Upper Pliocene and Holocene periods (Soligo et al., 2002). By the Late Pleistocene period there were multiple filling and erosional events due to the fluctuation of the streams in Rieti as well as the Velino Valley (Calderini et al., 1998).

2.2.1 Soil and geology

The alluvial soils in the Velino Valley accumulated over time. The Geoportale Regione Lazio database uses a digital map which identifies the lithological formations, geological formations and sedimentations within the province of Lazio.[3] There are several different geological sediment types within this study area, the most prominent of which are clay, conglomerate, limestone, travertine, gravel and marl. These geological sediments lay the foundation for the soils of the Velino Valley, including calcarenite/limestone/ marl, gravel/sand/clay, and travertine rock. These sediment characteristics all have different agricultural potentials. The flatter plains contain the gravel/sand/clay, and the inclined hillsides have patches of travertine and calcarenite/limestone/marl. Relating this to agricultural production

[3] All datasets were retrieved from Geoportale Regoine Map database. https://geoportale.regione.lazio.it/maps/?limit=5&offset=0

ancient agronomists do mention soil types that are useful for agricultural purposes. Columella notes that farmers should incorporate clay to gravelly ground which would allow good crops of grain and fine vines (Columella, 2.15.4). This is useful advice to consider because of the presence of these soil types found within the study area.

2.2.2 Hydrology, Waterways and Marshlands

Water sources in the Velino Valley are another important natural feature. They were useful in the practical sense because water is essential for human survival and agriculture, but it was also a notable cultural feature in the valley. The Velino River is tributary river of the Nera River measuring 90km in length. It joins the Nera River near the city of Terni and passes through Rieti. The river continues through the Velino Valley and ends about 15km east of the community of Antrodoco into Peschiera Springs. Peschiera Springs is where the water is recirculated toward the city of Rome. The Velino River often flooded, and the river's alluvial plain between Antrodoco and Rieti and contained marshlands until the 1930's when a canal was created (Lorenzetti, 2021). During the Roman period, it was known to overflow its banks and to create small lakes within the area of *Reate* (speaking about the Rieti Basin) (Pl. Natural History, 17. 12.38). From the flooding fluctuations the Velino River, the river is regarded as a source of water within this thesis instead of a water source used for navigation in the Velino Valley. The Rieti Basin area experienced periodic flooding from streams that also created wetlands in the basin. A prominent lake feature found in the Rieti Basin was the ancient *Lacus Velinus*. Figure 2.3 shows how the area frequently flooded at the end of the Prehistoric period. What remains of *Lacus Velinus* are the large dark blue lakes in the map (*Lago di Ripasottile* and *Lago Lungo*).

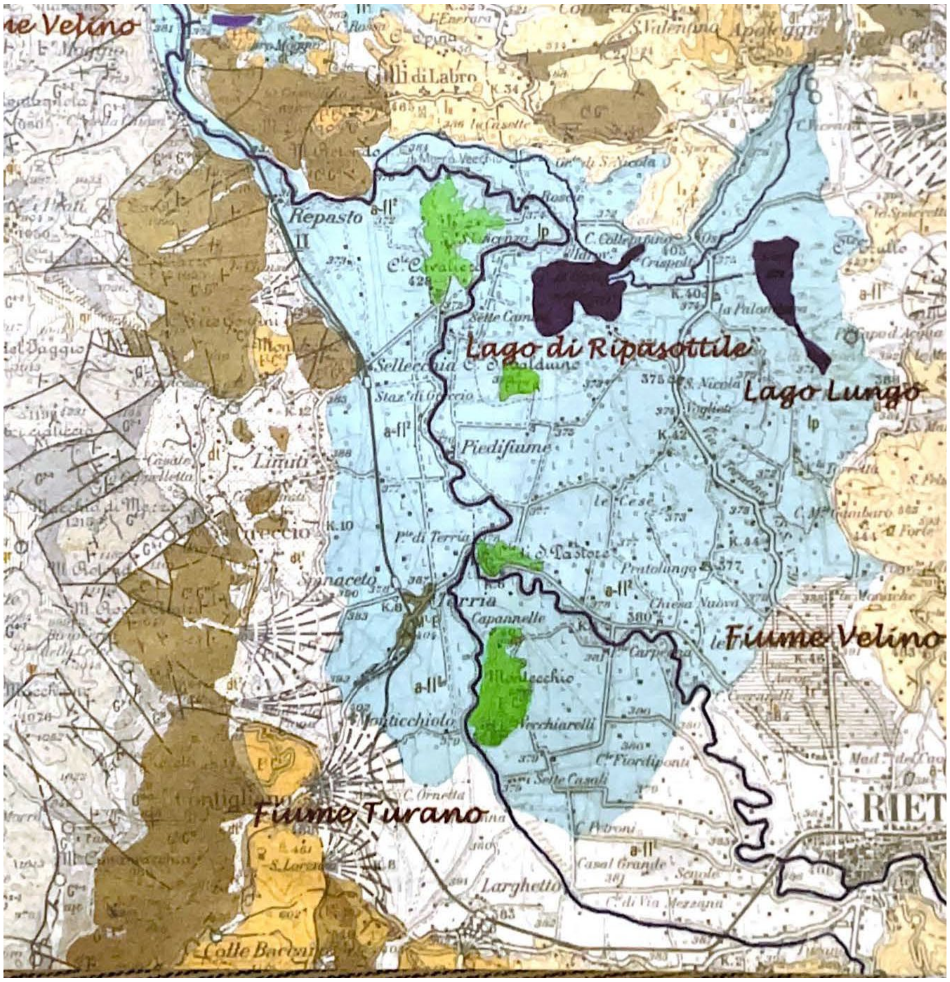

Figure 2.3: A map from Roberto Lorenzetti's book *Dal Velino alla Cascata delle Marmore: uomini, aque architetti, bonfiche e grandi interessi tra Rieti e Terni dall'epoca romana al'900*. The image shows the ancient lake in prehistoric times and the darker blue is what remains of the lake in the modern landscape and the green are the hills that were still visible when the flooding occurred.

In antiquity, the basin was drained through the intervention of the Roman general M. Curius Dentatus during the third century B.C.E, at the beginning of Roman control in the region. It was done as a cut through a tufa ridge and created the precursor to today's Marmore Falls (Cascata delle Marmore) (Schoolman et al., 2018). Marmore Falls is located to the northwest of the Rieti Basin and is ca. 26km from Rieti and 7.7km away from the closest city Terni. This lowered the water levels and created more areas for cultivation in the now drained Rieti Basin. Despite this, the basin would continually flood throughout history. There are sources from the

Middle Ages and Early Modern period (18th century) which show that there were occasions where interventions were made along the Velino River to better support communities around it (Lorenzetti, 2021). These interventions would incorporate the Rieti Basin and Velino Valley. The basin went through additional reconstruction in the 1930's when a water canal was constructed to control drainage (Coccia et al., 1992). This modern drainage system would end the continual pattern of flooding of the landscape. The removal of continuous flooding in the modern period allowed those living in the area to have minimal flooding on their property.

The Lago di Paterno (ancient *Lacus Cutiliae*) is another important body of water that is prevalent in the landscape and mentioned by historical sources (Figure 2.4). Geologically, it is a karstic lake, which is a common landform within the Apennines of central Italy. In antiquity, the lake is connected to the worship of the Sabine deity Vacuna. Ancient authors note that it once contained a "floating island [was] formed from the incrustations of carbonate of lime on the banks, which, becoming detached, probably collected in the middle" (Pl. Natural History, 3.17. 43). The island and the lake itself were two parts of a single cult site (Dion. 1.15.2).

The final body of water that is present in the Velino Valley is the *Cotilia Terme*. These were sulphurous waters that were in use from ancient times to modern day. They were known for their healing properties. Sources like Pliny (31.6) and Suetonius (8.21.1) reference that Romans came to these waters and mention the Emperors Vespasian and Titus both seeking the healing waters. This area was well documented historically in the first century C.E.

Figure 2.4: The image is of the Velino Valley from the commune Paterno which is to the north of the Villa di Tito site. It gives a good visual of the Lago di Paterno which was believed to be the geological naval of Italy, meaning being the center of Italy. Image was taken by Rebecca Payne in 2022.

2.2.3 Climate

Climate is a variable that provides context to the period of interest and affects the suitability of settlements. The climate helps interpret how much of an impact it exerts on the landscape. It can help with distinguishing what were anthropogenic changes and what were natural changes that influenced climate. This is done through an estimation of what the climate was like in the past. Climate is relevant for this research because it is important to know what the climate was like in the period of interest. In the past there were phases of cooler and warmer periods, and the increase or decrease of precipitation and knowing what occurred in the period of interest can help show whether there was a lot of weather conditions occurring. For this thesis, the interest is to know what the climate was like for the Imperial period of the Roman empire within Italy.

The general climate during the Roman Empire (ranging 1st century B.C.E to 2nd century C.E) on the Italian peninsula followed a stable period which had a warmer and drier climate compared to flooding periods or cooling periods (McCormick, 2012). Following this, during the Late Antique period of the 4th to 6th centuries, annual rates of precipitation were on the rise (Manning, 2013). Between 600 and 870 C.E it is believed that the area experienced above average-to-average precipitation. Isotope data from Pergusa Lake in Sicily indicates that southern Italy was also wetter between 450 and 750 C. E (Sadori et al., 2015). The climate information is useful to show there was not variation in the climate for the period of interest. For the period of interest (1st to 2nd centuries C.E) the climate analysis researchers have done in the past shows that it was a period of stability in comparison to the wetter and cooler periods which arose in the Early Middle Ages and in the contemporary context of being wetter and warmer.

2.3 History

2.3.1 Villa di Tito History

The aim of this section is to understand the archaeological history of the Villa di Tito. The Villa di Tito is the focal point of much of what follows in this thesis. The area itself is composed of the villa, a farmhouse with a basement museum and a gravel parking lot. The villa is described as "a terracing wall, about sixty meters long and eleven meters in height, it formed a façade with thirteen rectangular niches and alternating with fourteen buttresses" (Nardelli 2018, pp. 184). Figure 2.5 shows the buttresses and terrace that are exposed, and Figure 2.6 is a plan of all the rooms excavated in 2018, 2019, and 2022.

Figure 2.5: Low altitude oblique aerial image of the Villa di Tito that was taken during the 2019 excavations.

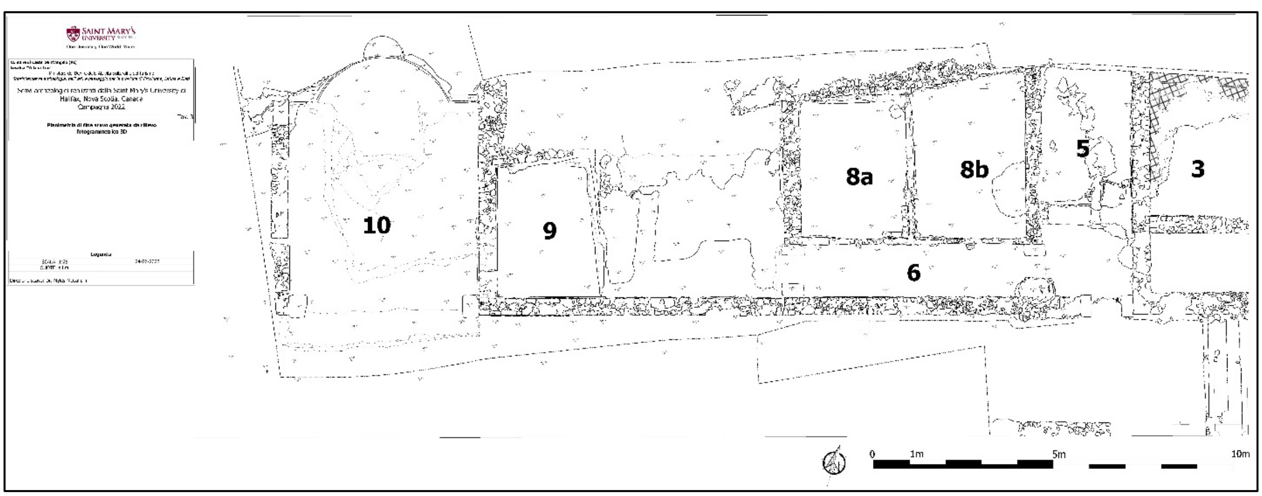

Figure 2.6: Site plan created at the end of the 2022 excavations on the Villa di Tito. The plan is focused on the rooms that were excavated on the terrace. The plan was created by Marco di Lieto & S.R.l.

Within contemporary works the earliest mention of the Villa di Tito is in Niccolò Persichetti's 1893 book *Viaggio Archelogico sulla Via Salaria nel Circondario di Cittaducale*. This is a narrative of Persichetti's travels along the ancient Via Salaria in the Sabine region, including detailed descriptions of ancient sites he visited. He identifies the site as a massive complex that may potentially have been a bathhouse and he describes the monumental pilasters that supported the terrace (Persichetti, 1893). This sparked an interest in the area, but the first actual archaeological investigation of the Villa di Tito was not until 1987. The Archaeological Superintendency of Lazio hired architectural conservators to clean and consolidate the site (Nardelli, 2018). This meant that the brick work around the columns were restored.

The first systematic and scientific excavations took place at the site in 2010/2011, under the direction of Giovanna Alvino, her team discovered that the rooms within the complex were consistent with a villa not a bathhouse. A wall structure found that connected the three different rooms was exposed south of the wall which was built into the natural bedrock (Alvino, 2012). In addition to the restoration and excavation of the site, GPR and magnetometry analyses were conducted on a portion of the villa which showed evidence of additional subsurface structures (Piro et al., 2013).

In 2018, 2019, and 2022, Saint Mary's and McMaster Universities conducted additional field excavations. The results showed the villa has a long terracing wall within the bedrock and exposed a total of 10 rooms (Figure 2.6). that followed an east-west orientation (McCallum et al., 2019). From these inquiries, the villa had an initial occupation period in the 1^{st}-2^{nd} century C.E and was a rustic villa. The villa appears to have been abandoned abruptly. This conclusion was found due to the lack of materials discovered dating past the 2^{nd} century C.E. At the villa there was evidence of reoccupation in the 7^{th} – 8^{th} centuries based on radiocarbon dating material from a hearth during 2019 excavations. Another GPR survey was completed in the summer of 2021. There were two sample areas which were in front of the farmhouse built to the east of the villa site and in the olive orchard of the farmhouse. The results indicate a subsurface structure of unknown date to the south of the farmhouse while the results for the olive orchard are less clear (Pomar and Kay, 2021).

Field excavations continued in 2022. The Roman-period rooms discovered in 2018/19 were more defined or completely excavated to floor level and test pits were dug in the lower portion of the cryptoporticus. From the 2022 excavations, the floor level was found in all of the previously exposed rooms.[4] From the excavation's material evidence as well as floral and fauna evidence was collected in the rooms excavated. One interesting discovery that was found was Room 8 that was exposed in previous excavations was actually two rooms with evidence of revocations. This further provides evidence of renovations present in other rooms instead of just having the room 10 addition.

The Via Salaria was an ancient roadway that crossed the Apennines connecting Rome to the Adriatic Sea. The road was named in relation to the route being used for collecting and trading salt. The road itself was built during Roman expansion (5th to 4th centuries B.C.E). When constructing the Via Salaria, it was known that the road followed the same route as previous drove roads used for travel and herding within the basin. The drove roads date as far back as the Late Italian Bronze Age (13th century B.C.E) and there is archaeological evidence connecting the drove roads to the late Bronze Age and Early Iron Age (12-9 B.C.E) (Coarelli, 1988). The road passed next to the neighbouring site of the Baths of Vespasian and must have passed near the Villa di Tito. In the modern landscape the road mostly aligns with the modern highway that

[4] Field report for 2022 excavations on the Villa di Tito is pending publication.

passes through the valley. On the Baths of Vespasian site, there is a section of the road exposed (refer to Figure 2.7). The Via Salaria was an important presence on the landscape.

Figure 2.7: To the southeast on the Bathes of Vespasian there is a portion of exposed remains of the Via Salaria. Image was taken by Rebecca Payne in 2019.

2.3.2 General History of the Sabine Territory

2.3.2.1 Roman Period

The Velino Valley is within the Sabine region, which was once claimed as the homeland of the Sabines (*Sabini* in Latin). The *Sabini* were an Indigenous group with origins in the Late Iron Age. In 290 B.C.E the Romans expanded their territory and came into conflict with the Umbrians, Etruscans and Sabines during the third century B.C.E. The Sabines were eventually brought into the empire through this primary contact and the establishment of an urban center as a point of contact with Rome. *Reate* (modern Rieti) was a beneficial town because it connected the interior Sabina to Rome. They had limited influence on the political sphere of Rome. The expansion was not unanimous and multiple military settlements in the Sabine Territory were founded in the lowlands during the expansion period. The new urban centres enabled the transition to a more Romanised way of life. They would eventually gain additional rights and Roman citizenship within the Republic during the Social War in 91 B.C.E. which united the peninsula. Similarly in Umbria, settlement types within the region's mixed terrain ranged from hillforts and villages in the mountains, to urban centres in the lowland (Bradley, 2000). The lowland settlements were more related to the roadways because they created a connection in the peninsula and capital. During the Late Republic and early Roman Empire there was a rise of Roman elites owning/ constructing a private villa that was away from the city of Rome. Many of these villas were near the city because there was a need for constant contact with Rome. Specifically looking at the Villa di Tito, the nearest cities to the site were *Reate* (modern Rieti), the towns *Aquae Cutiliae* (near modern Cittaducale) and *Interocrium* (modern Antrodoco). These sites are all connected by the Via Salaria.

The Velino Valley contained the Via Salaria which provided a connection to Rome and many other urban centres. This connection is useful considering the amount of economic production that occurred in this area. Strabo's *Geographica* mentions that "the land of the Sabini was exceptionally well-planted with olives and grapes, and it also produced acorns in large quantities; it is important, also, for its domestication of different types of cattle; and in particular, the fame of the Reate-breed of mules was remarkably widespread" (Strabo, 5.3.8). This statement gives an idea of what the Sabine region was known for and builds the basis for connecting potential economic ventures that the Villa di Tito could have participated in.

2.3.2.2 Late Antique Period

During Late Antiquity, the Empire underwent a gradual decline until it ended in C.E 476. Villa production was still a part of the rural economy in Italy in the early third century, but many previously villas were abandoned (Marzano and Métraux, 2018). Abandonment of these sites was due in large part to invasions, particularly in the 4th and 5th centuries C.E, and a shift of socio-political influences. This led to a breakdown of centralized political control and dispersal of people which caused settlements to fail and become abandoned (Arthur, 2016). Depopulation, some of which is related to invasions of the 5th and 6th centuries, was a contributing factor to regional economic decline and instability (Coarelli, 2009). Settlements were present through these declines but were not at peak production as they were in centuries before. There was still a presence of production in the late Antiquity, but it was not large and directed to Rome, but instead only supplied the local area (Arthur, 2016). This transitional period led to a new order of settlements within the rural areas. This is the period where the *vicus* type of settlement is prevalent. A *vicus* (or village) typically came to be based on a group of people who settle in areas near major roads, stations or former public buildings dating to Roman times (Arthur, 2016). Villas were also another site that individuals often resettled in or around as well.

2.3.2.3 Early Middle Ages

In the early Middle Ages, there was a transition in the political situation within the Italian peninsula, which was no longer under the centralized control of Rome. This decentralization or political fragmentation resulted in a series of duchies, kingdoms, and the papacy controlling central Italy during the early Middle Ages. The Sabine Territory fell mostly under ducal and papal control. For the Sabines "the Duchy of Spoleto in the eight century was conditioned by its relationship with two external forces above: the Lombard kings in Pavia and the major powers based in Rome" (Costabeys 2007, p. 64). The reorganization of rural communities occurred frequently due to the change in power. The reorganization led to changes in the physical landscape. This was due to deterioration and maintenance of structures used to minimize flooding. This occurred within the Rieti Basin and Velino Valley. The persistent flooding caused people to move to the surrounding hillsides near the Velino River (Betori, 2021).

Though there was a new overarching power, the rural sites continued to be economically productive. Agricultural production and transhumant pastoralism of sheep and large-scale wool production were present in the central Apennines (Wickham, 2006). Oleoculture was still prevalent after the Roman era which can date "between the eighth and thirteenth centuries, the olive tree was planted all over, even on the rocky ridges of the Alta Sabina, or northern Sabina (today the province of Rieti)" (Zanini De Vita 2013, p. 75). Aside from agropastoral production forestry was another venture that was present in the Sabine area. The historical records specific to Rieti indicate~~s~~ that the Lombards constructed buildings made of wood which were frequently replaced, and they valued the production of livestock, especially pigs (Mensing et al., 2018).

Despite these social and political changes over many centuries, the Apennines continually referenced pastoralism and agriculture in the Velino Valley. The landscape was consistently used as an area of agropastoral production, and this research focuses on the agricultural and pastoral potential of this region during the first and second centuries C.E. It also demonstrates why certain activities persisted to the present day.

Chapter 3: Methodology

My thesis addresses two main research questions, and each question requires two separate methods. To reiterate the research questions, they are:

> *What environmental, economic, and cultural factors influence the Villa of Tito's placement within the Velino Valley?*
>
> *What are the travelling patterns and network connections of the Villa di Tito to other archaeological sites in in the Roman period?*

The first part of the analysis will examine (3.1) sample of twenty-four villas located within the Sabine territory and attempts to identify any patterns associated with a series of natural features connected to each villa. The analysis was completed by quantifying and distinguishing any natural overlap between multiple villas based on the natural characteristics found. Villas and other archaeological sites sampled for this analysis were collected from multiple sources such as Marzano's (2007) book *Roman Villas in Central Italy: A Social and Economic History,* Talbert and Bagnall's (2000) book *Barrington Atlas of the Roman World Barrington Atlas of the Greek and Roman world* and the database from the Digital Atlas of the Roman World. Figure 3.1 shows a map of all the chosen sites to help answer both research questions. By having the comparisons, we can see if these sites can help show whether the Villa di Tito fits into a regional pattern of a villa placement in the landscape or if it is unique.

The analysis to address the second question (section 3.2), focuses on determining optimal paths as a line. The optimal paths originate from the Villa di Tito and aim to connect the site to other sites like cities, towns and road stations. This analysis provides a context of how connected the Villa di Tito is to other sites in central Italy. The paths will reflect whether there is a more efficient way for the owners and the products made on the villas to move through the landscape compared to what is found from known Roman roads. To answer both research questions ArcGIS Pro version 8 was used for all analyses.

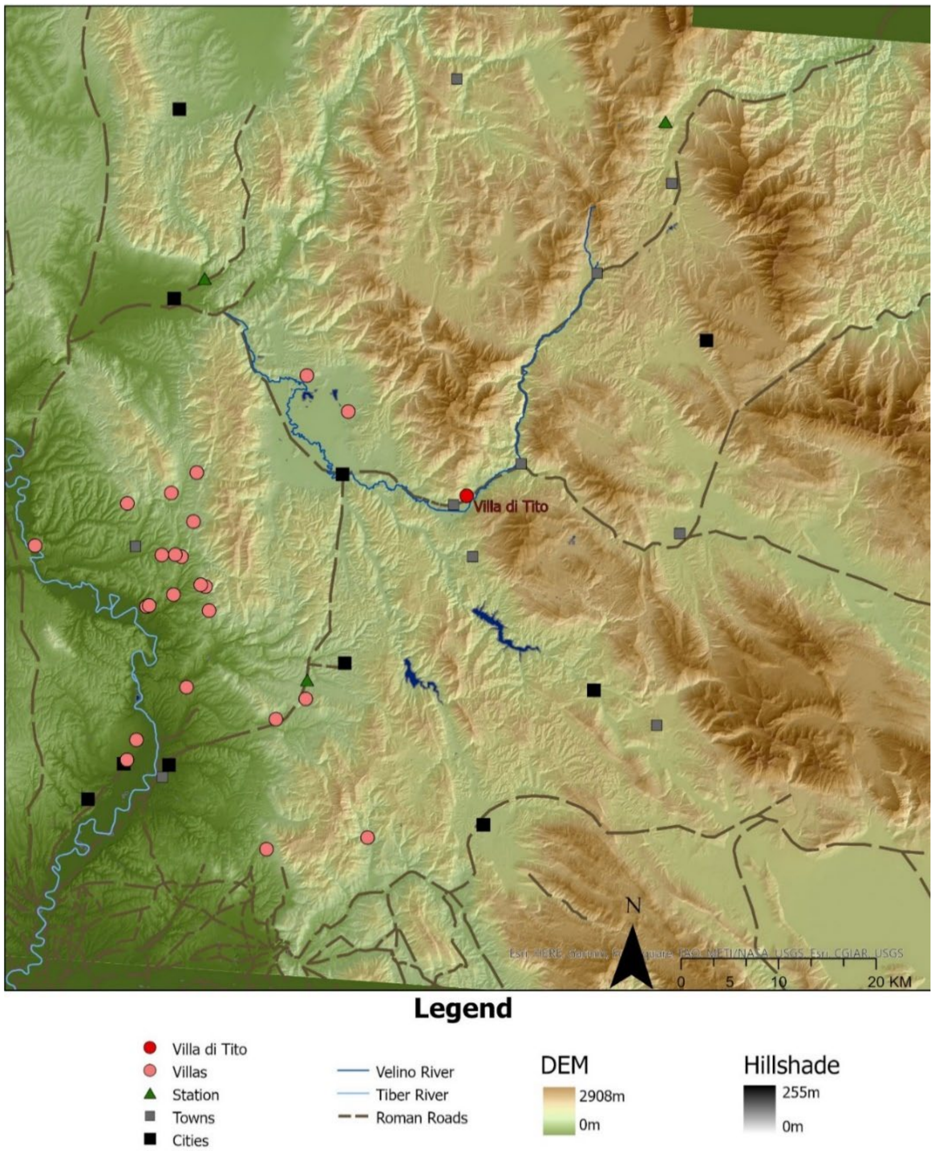

Figure 3.1: Location for all archaeological sites that are of interest for this research. The villas in pink are for the first research question and the cities, towns and station are related to the second question.

3.1 Villa Characterization

This analysis was conducted as a multiple step method beginning with assigning attributes to each villa to compare and characterize them. These values were from natural characteristics for each site and were derived from GIS raster layers such as slope, elevation, aspect, geology, and solar radiation. These characteristics listed were chosen for two main reasons: first, they can be compared to data generated by other researchers as well as descriptions written by ancient Roman agronomists; second, these datasets were the most accessible both in being created in ArcGIS Pro and datasets derived from the database Geoportale Regione Lazio[5]. The values were extracted using Extract Values to Points toolset in relation to the villa sites. This means the x and y coordinates placed on the villa site is where the values for the dataset's elevation, slope, aspect and solar radiation were derived for use in this analysis. These data values were then added to an attribute table and can be referenced in Appendix A.

Dataset	**Layer name**	**Datatype**	**Cell size**	**Source/ where it was derived from**
Elevation	CnItaly_DEM_TI10m	Raster	10m	TinItaly[6]
Slope	Slp_CnItaly_DEM_TI10m	Raster	10m	Derived from TinItaly DEM
Aspect	Asp_CnItaly_DEM_TI10m	Raster	10m	Derived From TinItaly DEM
Geology	Geology_Raster	Raster converted from polygons	10m	Geoportale Regione Lazio
Solar Radiation	SolRad_Season	Raster	10m	Derived from TinItaly DEM

Table 3.1: Shows the datasets that are used to for extracting values for each villa and archaeological site. DEM is Digital Elevation Model, which was used to derive the majority of the datasets displayed in this table

[5] The map database from Geoportale Regione Lazio is found on the following link: https://geoportale.regione.lazio.it/maps/?limit=5&offset=0.
[6] The DEM dataset used for creating additional datasets were downloaded from TinItaly. https://tinitaly.pi.ingv.it/Download_Area2.html

The method to conduct this analysis relies on building a comparison of villas based on the PhD dissertations of Goodchild (2007) and Viitanen (2010). Both contain a similar framework in which they compare variables to understand a villa's location. Goodchild focuses on the agricultural component to build a model showing the realistic projection of agricultural production in Southern Etruria/ Sabine region that surrounds the Tiber River (Goodchild, 2007). Viitanen's work was an examination of villas found in the Roman Campagna and shows whether the villas follow the instructions of agronomists and if there are beneficial or problematic locations found in this specific region (Viitanen, 2010). My research expands on their work with including the writings of Roman Agronomists, Cato, Columella and Varro. Additionally, Pliny the elder's encyclopedia titled *Naturalis Historiae* is also used. Table 3.2 shows basic information on the sources that will be addressed in this research.

Author's name	**Life span**	**Time period**	**Book Title**
Marcus Porcius Cato (Cato the Elder)	234-149 B.C.E	Roman Republic	De Agricultura
Lucius Junius Moderatus Columella (Columella)	4- 70 C.E	Roman Empire	De Re Rustica
Marcus Terentius Varro (Varro)	116-27 B.C.E	Roman Republic	De Re Rustica
Gaius Plinius Secundus (Pliny the Elder)	24- 79 C.E	Roman Republic	Naturalis Historia

Table 3.2: The table above helps give an idea of when the agronomists were alive, therefore an estimation when the works were published.

Each villa was examined and compared with respect to a number of variables or characteristics. For elevation, slope and aspect map distributions were made to visualize whether there is more overlap in similarity for one characteristic then the other. For example, the range of elevation for the villas can help determine if villas were constructed at similar elevations. Slope and aspect were reviewed to see if there was a specific slope angle and cardinal direction that villas were located on.

Geology and soil maps give us an understanding of whether there is a specific soil type that the villas were constructed on. The analysis was based on the geological map from the Geoportale Regione Lazio. The dataset itself is scaled from 1:25 000 and is based on the environmental origin, formation and sedimentation of the Lazio area (Carta Geologica, n.d). The dataset includes geological materials and or soils deposits. This was the highest resolution available online when colleting data. Each sample villa was given their geological label based on the placement within the raster dataset. This is then compared to the soil analysis found within Goodchild (2007) and Viitanen (2010) to build on what would be useful for the production potential of the sampled villas.

Lastly solar radiation was also reviewed to calculate the amount of solar radiation in each location (Solar Radiation toolset, n.d). Using Area Solar Radiation toolset, solar radiation raster maps were derived from a Digital Elevation Model (DEM) and represent each season to see the amount of sun coverage of the sample villas sites based on the seasons. The inputs needed to show the solar energy projections are derived from three important parameters. They are the latitude for the site, time configuration (which shows what time period is of interest) and the sky size (Solar Radiation toolset, n.d). The values used for latitude and sky size were given from the tool and based on the DEM raster used. For the time configuration, the dates were in related to the dates of the meteorological seasons. Lastly the intervals that were used for noting the sky sectors used to collect the solar values were based on a weekly interval of every half an hour. Typically, the toolset uses biweekly, but the weekly interval incorporated more intervals to be taken into consideration for the sun's placement in the sky. Solar Radiation allows for an analysis on how much solar energy reaches each site and whether or not they were in a location with high solar energy. This feature can relate back to the seasonal practices the agronomists recommended for agropastoral ventures and whether there is physical overlap through all the sample villas.

3.2 Connectivity through Optimal Paths

Optimal path as a line tool in ArcGIS Pro was used for this analysis. It provides a visual depiction of how connected villa sites were to nearby urban centres and road stations. This will connect the Villa di Tito to its surroundings to show travel patterns within the Apennines. With this research I incorporate elements of two articles by Carreras et al. (2019) and Field et al. (2019). The main goal of Carreras et al. article was to digitize the Roman Transport network and obtain reliable information on the distance information of each of the transport networks (Carreras et al., 2019). Based on their research, the authors refer to many different approaches to create these digitized least cost paths. Field et al. (2019) research focuses on giving more insight on how Ancestral Pueblo people of the Four Corners, southwest planned, engineered, and were physically connected to places across the Chaco landscape. Both researcher's methods helped guide the methodological design of this thesis. By combining these two methods a model (Figure 3.2) was created for making the optimal paths.

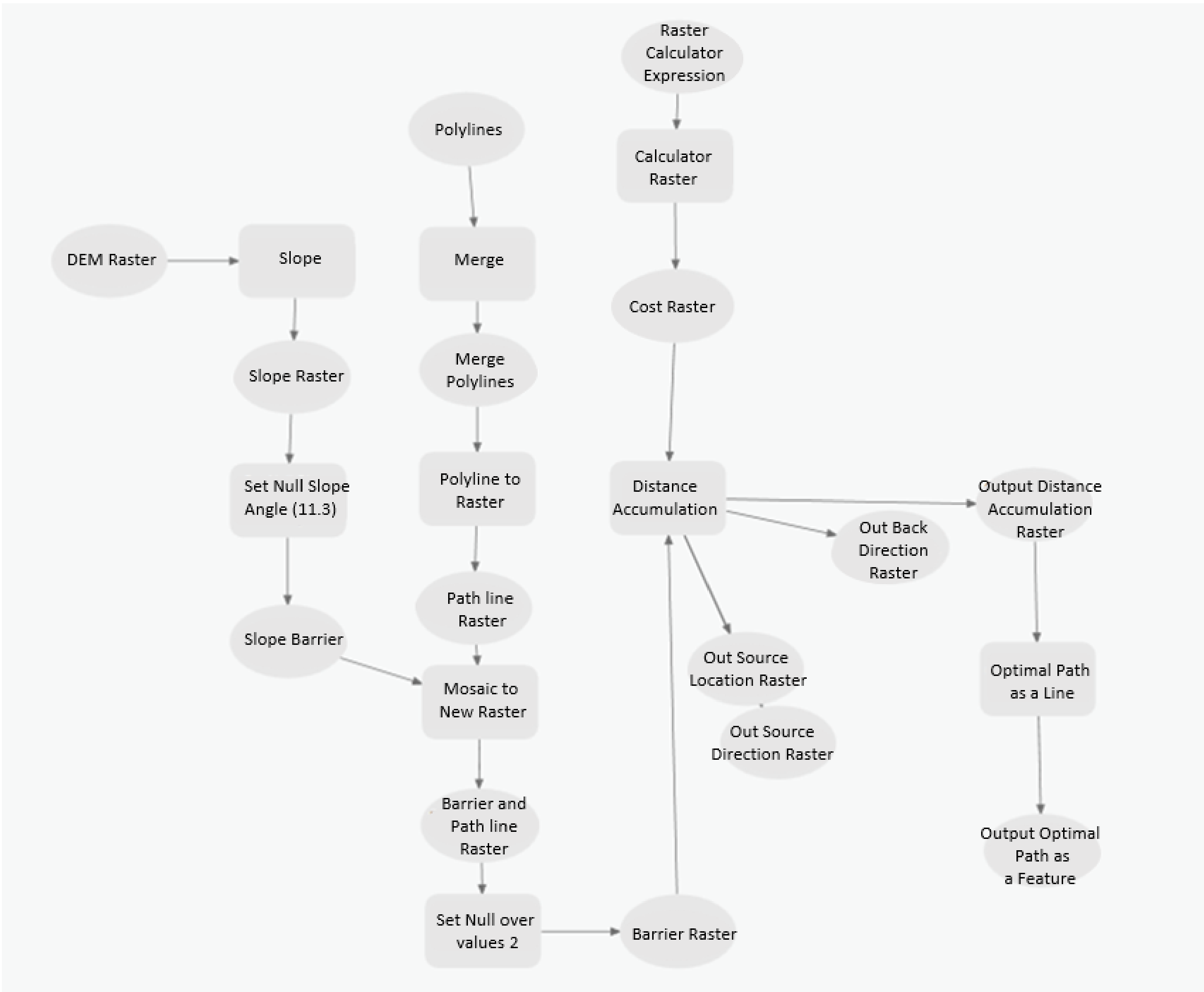

Figure 3.2: Model of all the steps that were taken to create the optimal paths as a line for this research. The model's squared text box is the toolset used and the circular text box is the dataset used.

To begin this analysis, a cost raster and distance accumulation raster were created to address how much energy was needed to travel between raster cells and what areas within the villa's vicinity would be the least cost over which to travel. Pandolf et al. (1977) research on predicting energy expenditure from walking was applied here.

Pandolf et al. (1977) equation (refer to Figure 3.3) is used by several researchers (Field et. al., 2019: Güimil-Fariña and Parcero-Oubiña, 2015) to understand mobility and connectivity in past landscapes. For the load (L) and body mass (W), I choose an average weight of 185lbs (84kg) for an individual. The load mass was another average mass that could be carried by someone (24kg). For the terrain factor (ŋ) 1.0 t has been used for travelling the value due to its representation being a paved roadway. This was due to most Roman roads being paved by the 2nd century C.E (Laurence, 1999). ORBIS: The Stanford Geospatial Network Model of the Roman World project was reviewed for movement in the past and to provide the velocity (V) commandant needed for this equation. For velocity value used was 30km/day (converted 30 000m/86400s) which takes into consideration "foot travellers including armies on march, pack animals with moderate loads, mule carts and camel caravans" (ORBIS, 2015).

$$Mw = 1.5 * (W)+2.0*(W+L) * (L/W)^2 + \eta * (W+L) * (1.5 * V^2 + 0.35 * V * G)$$

$$Mw = 1.5 * (84) +2.0*(84+24) * (24/84)^2 + 1.0 * (84+24) * (1.5 * 0.3^2 + 0.35 * 0.3 * G)$$

<u>Symbols</u>

Mw = metabolic cost of walking (in watts)	W = body mass (kg)
L= Load mass (kg)	ŋ = Terrain Factor
V = Velocity (m/s)	G= Slope or grade

Figure 3.3: Shows the equation created by Pandolf, Givoni & Goldman (1977). The second are the values filled in for the cost raster made for this analysis.

The last step is to create the optimal paths as a line. This was created showing the Villa di Tito's optimal paths to cities, towns, and road stations. There are limitations that must be considered when applying the optimal path as a line for this work. Referring to Figure 3.4 you can see the paths from the Villa di Tito are straight lines and do not account for the mountainous terrain of the Apennines.

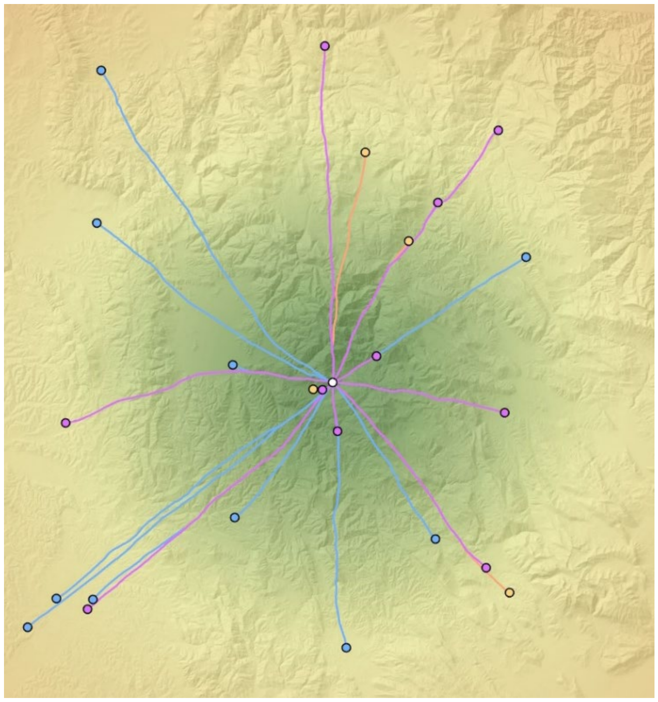

Figure 3.4: Sample of inconclusive optimal paths as a line laid over a digital elevation model of the Velino and Rieti Basin. The terrain is faintly seen which these lines do not account for.

To account for slope in the Apennines there were additional constraints added to the slope raster. Carreras *et al.* (2019) references multiple works that showed various inclines that can be considered navigable. Herzog (2013) estimates 8-10% in Rhineland, Grewe (2004) 8% Verghan and Jeneson 15% in Limburg (Carreras et al., 2019). To distinguish the navigable incline in the area the slope angle from Verghan and Jeneson was applied. The angle range chosen from their results addresses what would be navigable for wagons led by animals. The general incline that was presented by Verghan and Jeneson was 15% (or 8.53 degrees). Carrera's et al. (2019) also remarks that there could be a 16- 20% gradient but there were no site examples for these values. When applying this, I applied 20% (11.31 degrees) to make sure there was flexibility when creating the paths. There are multiple inclines within the Apennines, and a slight incline increase provides a better display of potential paths. To remove these values that are above 11.31 the Set Null geoprocessing tool was applied to the slope raster to null the slopes that are not navigable (refer to first column in Figure 3.2). This is applied to the cost raster that was created. From the results a more detailed analysis of the known path of the Via Salaria was completed. This was to further understand how the road is related to the Velino Valley and Rieti Basin.

The aim for the optimal paths was to compare the Via Salaria to show whether it was placed within the landscape for efficient travel. Both the paths and Via Salaria can be compared and show whether there was an efficient way of travel or where additional considerations were found for the construction of the Roman Roads. Comparing the Via Salaria to the route of the optimal paths is important for connectivity and economic purposes because it explores how the Villa di Tito is connected to these ideas.

Chapter 4: Results

The first section of the results reviews the terrain characteristics (elevation, slope, aspect, geology, and solar radiation) based on the 24 selected villas in the Sabine Territory. The analysis of these characteristics shows there is a lack of similarity among the villas sampled. A final component for understanding the Villa di Tito's physical placement and production potential is its connections to Roman roadways and water springs (Columella, 1.3.1, 1.1.1-4; Cato, 1.13). Based on the ancient recommendations the villas will also be analyzed in proximity to roads, rivers and lakes.

4.1 Villa Comparison

As noted previously, what follows is based closely on the methods of Viitanen 2010 dissertation: *Locus Bonus: The Relationship of the Roman Villa to its Environment in the Vicinity of Rome*. Viitanen's (2010) approach used archaeological and environmental evidence to analyze the locations chosen for building villas and if the villas used for farming follow instructions to match these locations. Viitanen worked in the Roman Campagna and looked at variables like geology, soils, water, terrain, visibility, and proximity to other archaeological sites such as towns and villages. My work also analyze terrain, geology and proximity of the villas to rivers, and roadways for the analysis that follows. However, my work focuses on villas that had been occupied from the 1st to 2nd centuries C.E during imperial Rome rather than looking at villas from the Republican period to the Late Antique period.

The terrain variables of elevation, slope and aspect are categorized according to the mean of the values (Table 4.1). The table is organized to show that each colour indicates how close the variable (elevation and slope) is to the average in each section. It provides a better idea of how many villas fall into each quartile. Overall, 18 villas also fall under or within the mean of elevation and slope. So, this shows there is a variation but there are not too many villas falling outside the regular percentiles. Dividing the villas in this way helps place where the Villa di Tito is ranked with the percentiles based on the prevalent values found within the sample villas. The Villa di Tito's location is in a higher percentile for elevation and slope, which is in the upper 25% within the range of the variables presented (Table 4.1).

OBJECTID	Site Name	Elevation	Slope	Aspect	Cardinal direction
1	Villa of Titus	503	24.38	142.63	SE
2	Villa di Orazio	396	2.13	62.1	NE
3	Grotti di Torri	159	3.01	160.01	S
4	Monte Calvo, Scandriglia	379	5.7	268.57	W
5	Villa di Lucilla	405	12.26	235.98	SW
6	Poggio Catino	384	16.22	101.68	E
7	Villa Vacone	388	16.25	147.45	SE
8	Ponte Capo d'Acqua	376	2.69	223.52	SW
9	Villa di Assio	408	9.64	167.22	S
10	Villa Baciletti	71	3.01	69.97	E
11	Villa Volusii	48	4.26	151.8	SE
12	Villa Monte Elci	310	15.99	322.96	NW
13	Villa S. Lucia	299	12.22	245.89	SW
14	Villa S. Maria Assunta	131	17.08	75.86	E
15	Villa Colli Rotti	126	8.98	159.97	S
16	Villa S. Adamo	110	3.92	192.43	S
17	Villa Terme Silla	286	8.16	232.89	SW
18	Villa Paranzano	271	10.21	234.73	SW
19	Villa S. Vito	251	2.13	151.91	SE
20	Villa Colle Tulliano	272	2.69	313.4	NW
21	Villa Foglia	91	2.86	268.24	W
22	Santa Maria Legarano	403	4.26	241.91	SW
23	Villa Cottanello	393	6.72	223.43	SW
24	Villa Grignano	302	9.64	167.06	S

	Elevation	Slope	Colour for each value
Min	48	2.13	
Q1	138	3.01	
mean	282	7.83	
Q3	391.75	12.25	
Max	503	24.38	

Table 4.1: The table provides the information of elevation, slope, aspect and each villas cardinal direction. It additionally is colour coated to follow the mean and quartile percentage for elevation and slope. This provides a better visual to show a pattern of where the value match in the villa sample.

Elevation was an important variable to consider because it indicates the vertical placement of a villa within the landscape. The primary sources for a villa's location in relation to elevation mentions the merits of being on a hillier terrain compared to flat landscapes. (Cato 1.2; Varro 1.6.2). Varro goes into more detail by stating the merits of a hillier placement compared to a flatter terrain and lastly a mountainous region. Cato and Varro also explain that these elevations minimize stagnant water and that higher up is more beneficial for specific plants to grow. With a closer examination of the elevations, it indicates that most of the sample villas are in a lower elevation. The villas were on the hillier terrain to the east of the Tiber bank and the pre-Apennines (Figure 4.1). The elevation is divided by hundred-meter intervals to maintain a simple classification and the values are displayed in meters. From the sample villas only four were in third and highest elevation category (Villa di Lucilla, Villa di Assio, the villa at Santa Maria Legarano) and includes the Villa di Tito. Breaking the elevation down further only eight are found in the 300-399 range, five in the 200-299m range and 7 being in 0-299m range. Regarding the two ranges with the highest volume of villas (300-399 and 0-299) it shows elevation was important to consider but not a feature specifically needed for a villa's placement in the landscape.

Slope is important because it shows what incline a villa is on within the landscape. Slope angles were found to be useful for both the placement of the physical villa and the production purposes on the site. Primary sources (Columella 2.2.1; Varro 1.6.2; Cato 1.22) agree that villas and farmsteads should be on a hillier slope or at the base of a mountain instead of being on the flatter plains. Columella details this best on why the hillier slope is more beneficial. According to the agronomists, the owners would benefit from growing grain, herd management and clear waterflow which would prevent water build up (Columella, 1.1.2-5, 5.2).

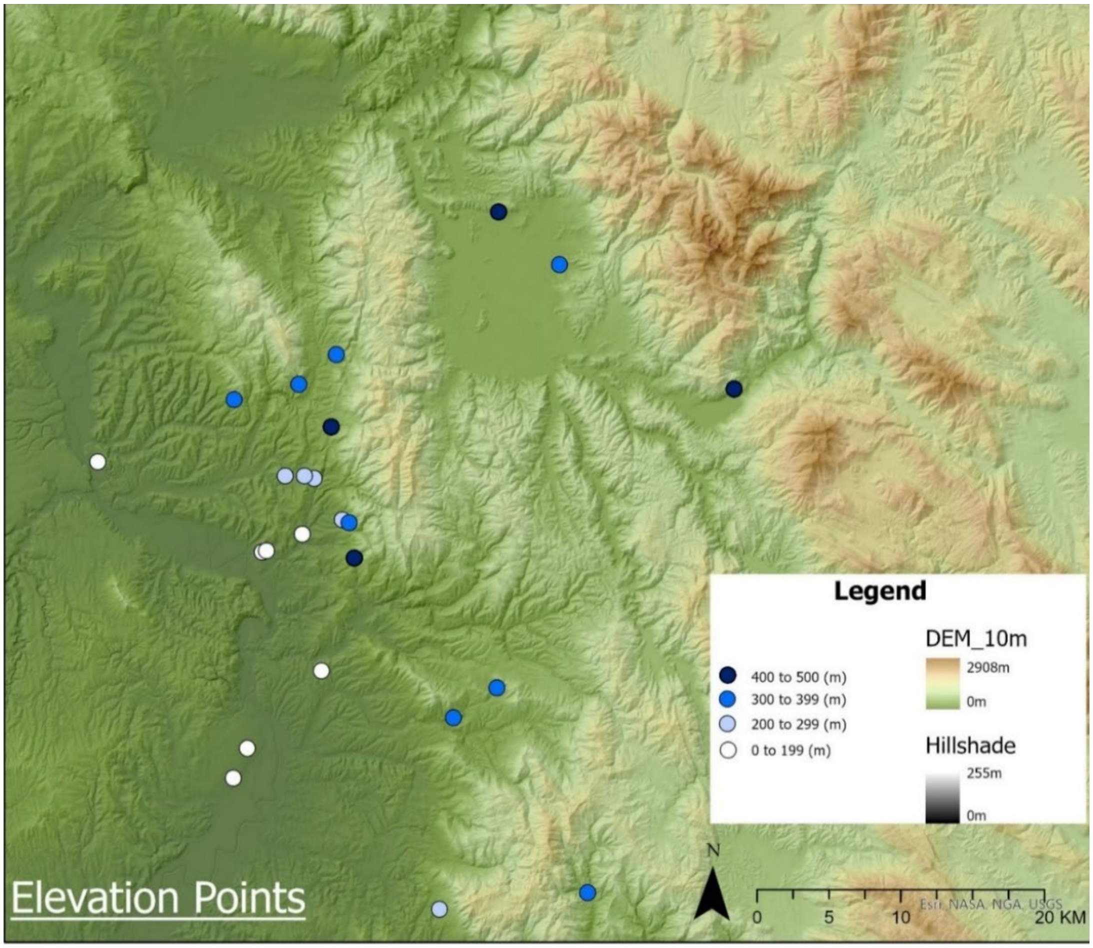

Figure 4.1: The map shows all the sample villas divided into 4 categories of elevation. It shows the majority found in the 0-299m and 300-399m.

Slope was divided into five main categories. The categories follow an equal interval, but the decimal incorporated is to make sure all sites fall into a category. From the initial observation, there are 10 villas located on the lowest gradient of 0.0-4.9 degrees. The second category with the highest number of villas present were reflected into values of 5.0- 9.9 degrees. The results show 66% of the villas fall below the range of 0.0- 9.9 degrees slope angle. This indicates that the villas were not on steep slopes but possibly were on a flatter terrain. All but one of the remaining villas roughly 33% fall into the gradient between 10.0- 24.9 degrees. The Villa di Tito has the steepest value as well as the only villa found in the 20.0-24.9 slope angle. This is one of the distinguishing features of the villa being in a higher value when comparing villas within the natural features.

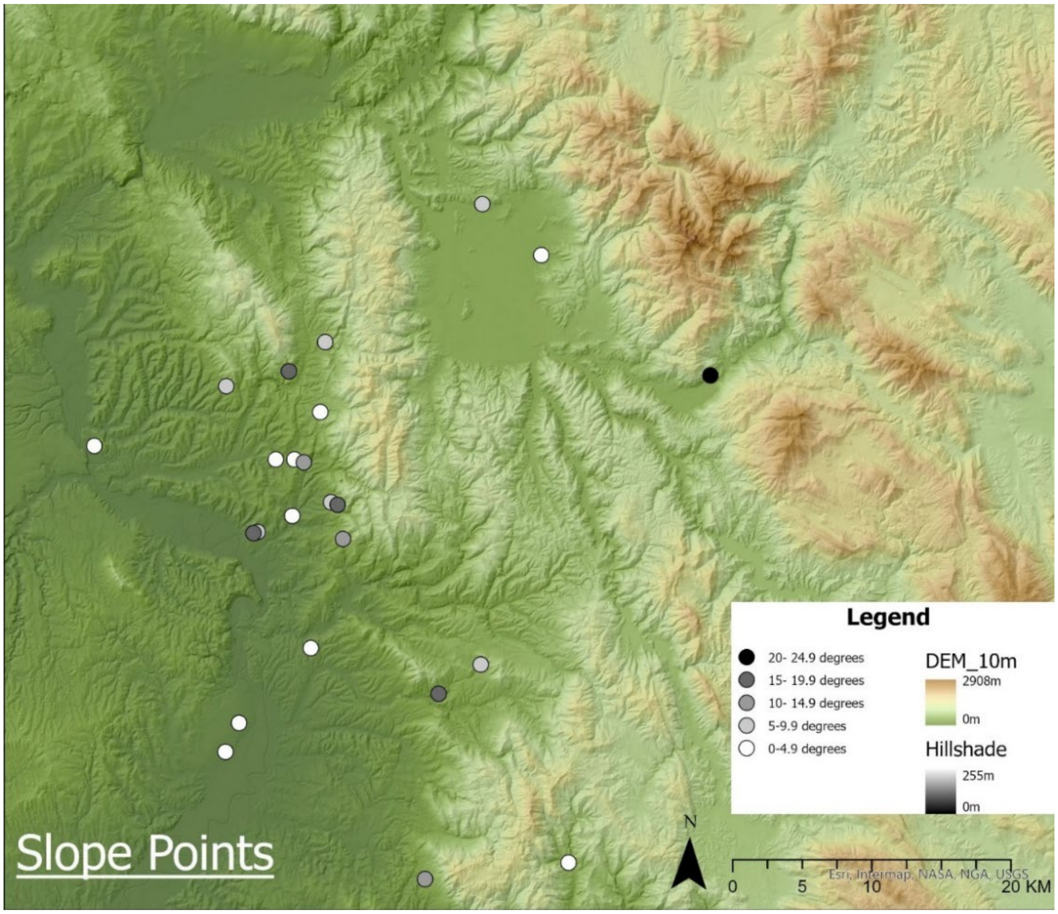

Figure 4.2: Sample of the villas divided into different slope angles and showing where there are more villas found within the 0.0-4.9 and 5.0- 9.9 slope angle measured in degrees.

Aspect refers to the cardinal direction relative of an incline (Aspect Esri, n.d). It is useful within the villa context because primary sources leave instructions on what cardinal direction a villa should face. From the primary sources, when placing a villa on a sloped terrain the general direction recommended is to face the east or south (Cato, 1.1.3; Columella, 1.2.3). This research found that 12 (50%) of the villas sampled followed these recommendations. The villas fall into the categories east, southeast and south (Figure 4.3) but 11 do have a western influence in the cardinal direction. None of the villas face directly north, whereas only 1 face northeast and 2 face north-west. The rest of the 9 villas fall into the southwest (7) and western (2) directions.

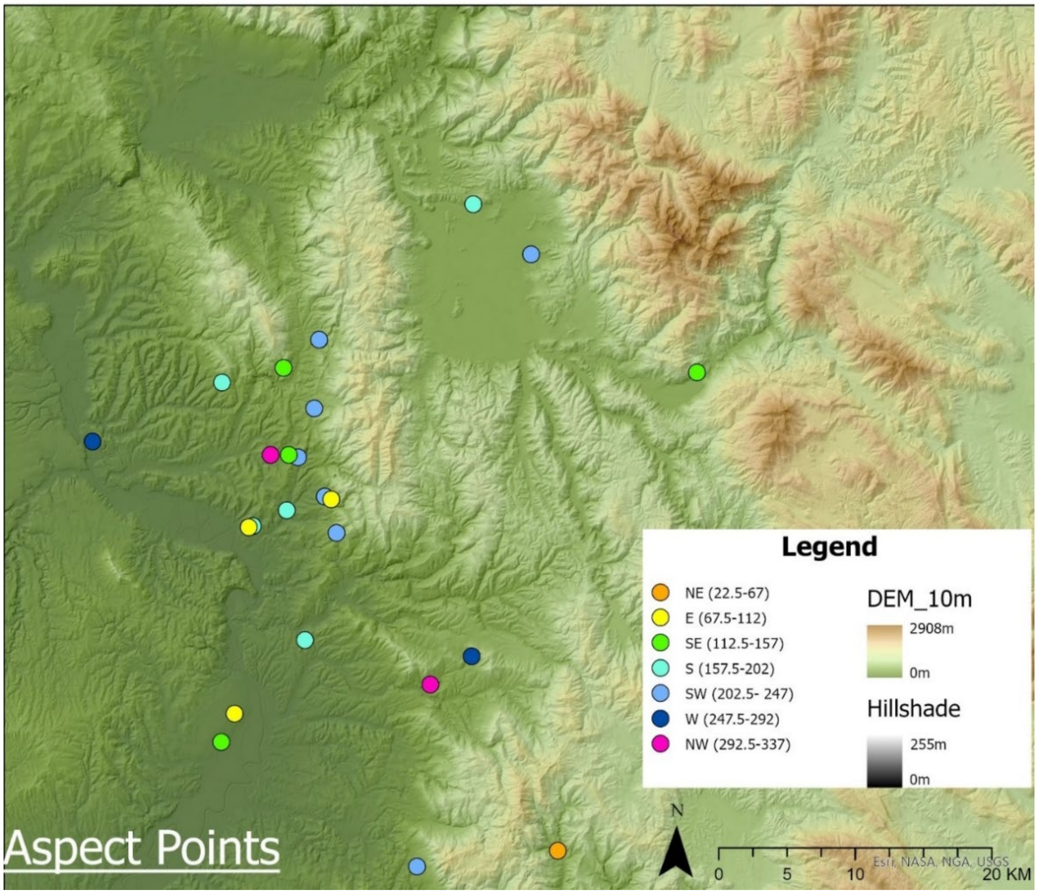

Figure 4.3: The map shows the cardinal directions for each villa using aspect. The directions E, SE and S are the feature that follow the agronomists recommended direction to face.

Solar radiation is a component that is useful for examining whether a villa has enough solar energy coverage required for agropastoral ventures. To do this, a raster was created for each season to see the average amount of solar energy found on the landscape (refer to Figure 4.4 for the raster images). The Area Solar Radiation tool allowed for the measurement of solar energy that averaged through hours of the day and solar position based on a weekly interval. This allowed for more variables on the suns position to be considered for an energy value in relation to each season. It is compared to all the sample villas to understand if they have the required solar energy for agricultural and other economic activities.

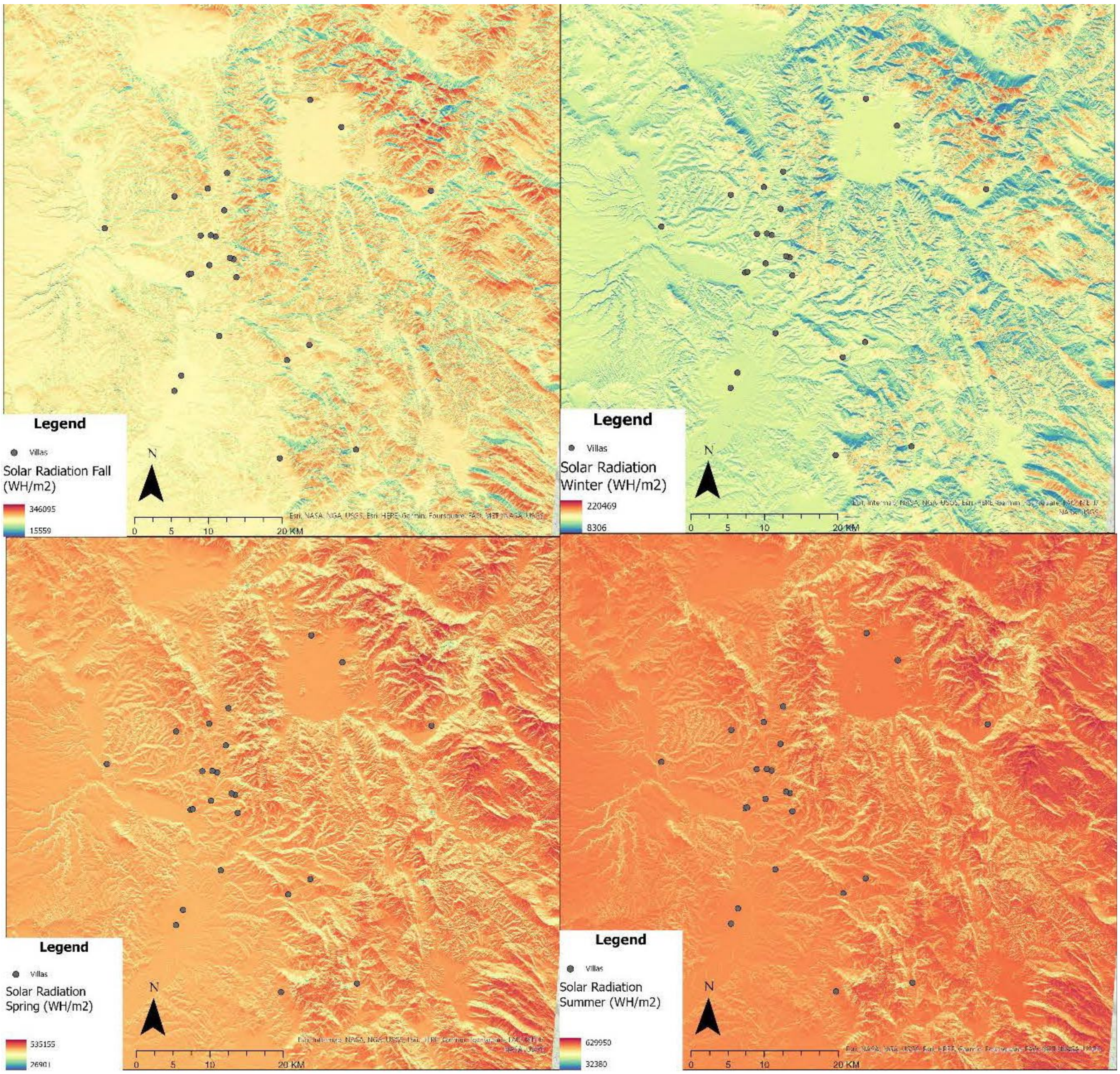

Figure 4.4: Amount of solar radiation in relation to the villa sites starting at the top left a) fall b) winter c) spring d) summer. The solar radiation visuals are expressed in $Wh{\cdot}m^{-2}$. The scales ranges vary due to the variation of solar energy due the sun's intensity on the landscape.

From the images, the villa samples in relation to each season do not have a large variation when compared to each other. The range of solar radiation for each season varies and they are the following, the summer by 50 000 $Wh \cdot m^{-2}$, spring from 65 000 $Wh \cdot m^{-2}$, fall 78 000 $Wh \cdot m^{-2}$ and winter 58 000 $Wh \cdot m^{-2}$.

Solar radiation shows that consistent solar coverage is on all the villa sites within the study area. All villas were also in an area with a full solar presence during all seasons. In the summer it was the peak season with the highest amount of solar energy (Highest value found at Villa di Assio measuring 510 900.09 $Wh \cdot m^{-2}$) projecting onto the landscape. Looking at the cooler season of the winter, all the villas fell into a medium amount of solar energy hitting the sites, therefore, showing all were in a consistent solar coverage. Solar radiation also brought an interesting discovery within the Velino Valley which is important to the Villa di Tito. The Villa di Tito has the best solar coverage/ energy absorbed compared to the southern mountains that encase the Velino Valley. Figure 4.5 shows that the hill slope of *Climata di Castello* where the Villa di Tito is located as more favourable compared to the base mountains in the south of the valley. The villa is located there is a steady amount of solar energy in the Valley compared to the southern mountain ranges that are covered by shadow and have less solar energy during the winter. This is because there is no shading which is good for both agropastoral ventures as well as temperature control within the villa itself. With reference to direct sunlight, it is worth linking consistent sunlight for a villa's placement and production potential within the landscape. The ancient agronomist's mention that consistent sunlight was needed for the growth of grains (Cato 5.1; Columella 2.9.3) and olives (Columella: 1.24.1).

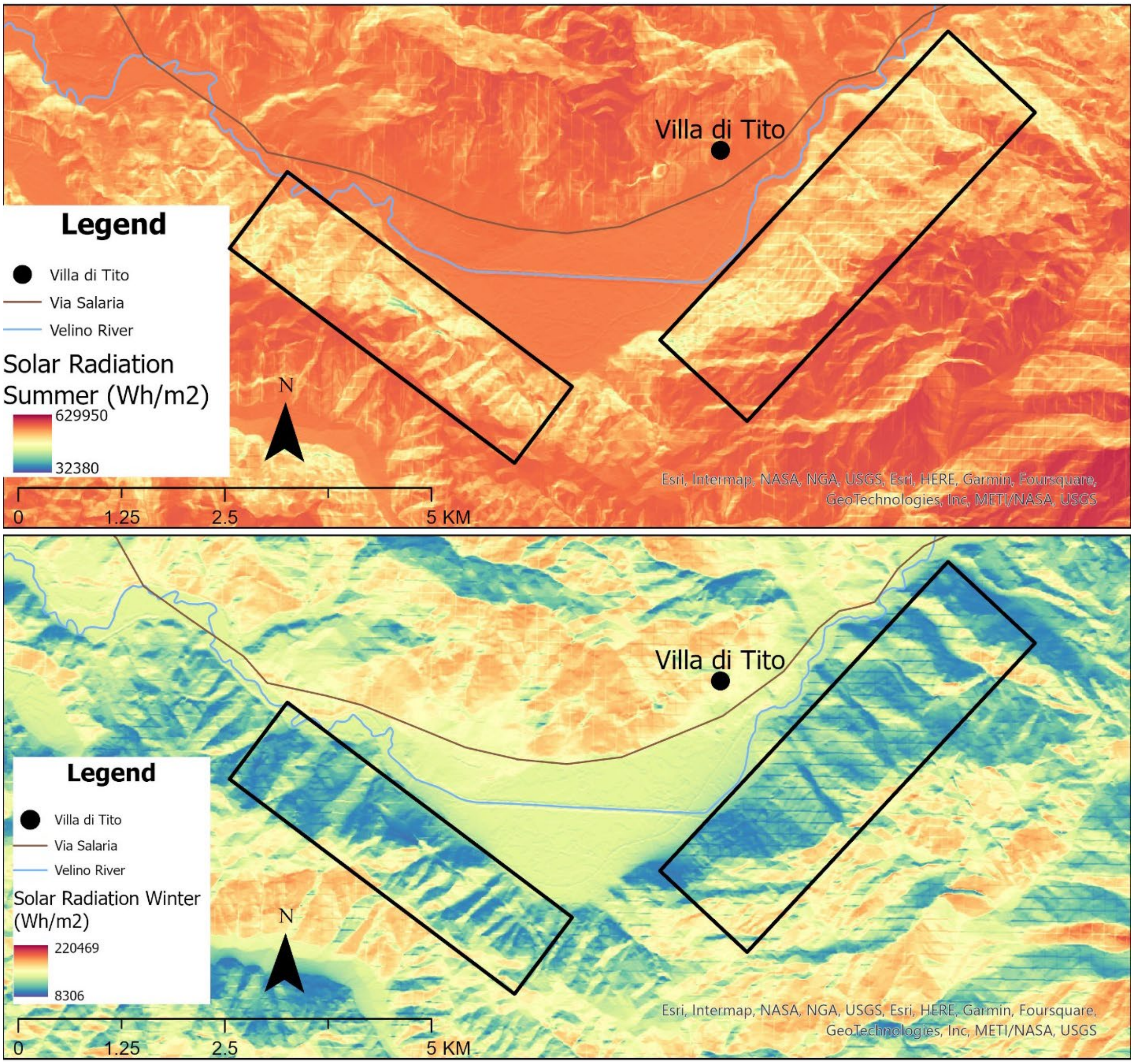

Figure 4.5: Solar radiation ($Wh \cdot m^{-2}$) of the Velino Valley. Focusing on the hill faces boxed in they markedly less solar energy compared to the Villa di Tito's placement this is useful because it shows that there is consistent sunlight on the site. This is important because the ancient agronomists refer to constant sunlight for agricultural production.

Looking into more detail, the villas were placed in order from highest to lowest to see if there were any patterns based on how the villas were listed. For this variable, it is important to know if there are locations near the villa sites that have a distinctively different amount of annual solar radiation. To begin, there was a particular threshold (in this instance minimum and maximum) to see if there were any patterns found in the solar radiation dataset. For all the seasons the Villa di Assio, Villa Vacone, and Villa Grignano had the highest temperatures. There were only three villas (Villa S. Maria Assunta, Villa Monte Elci and Villa Baciletti) that were consistently listed lowest in all the seasons. Elevation, slope, and aspect were compared to the highest and lowest valued sites to see if there are any additional connections to be made. The only connection that can be found in that 83% have southern and/ or eastern aspect directions but the other variable did not have a meaningful overlap. Having the aspect connection in mind the cardinal direction of east and south were the direction of interest according to the ancient agronomists. There is minimal overlap from the top three highest and lowest villas when adding elevation, slope and aspect to the solar radiation values.

Villa	**High or low**	**Elevation**	**Slope**	**Aspect**
Villa Vacone	High	388	16.2	147.4 (SE)
Villa di Assio	High	408	9.6	167. 2 (s)
Villa Grignano	High	302	9.6	167.1 (S)
Villa Baciletti	Low	71	3.0	69.97 (E)
Villa Monte Elci	Low	310	15.9	322.9 (NW)
Villa S. Maria Assunta	Low	131	17.0	75.8 (E)

Table 4.2: The table shows the 3 highest and lowest villas that were found within the top 4 lists of variables in all the seasons. Elevation (m), slope (degrees) and aspect (cardinal degrees) are listed per villa.

Geological data is needed because the villa structure requires an area that can be productive. To make sense of these soil/sediment features the aim is to see whether the geological features could support agropastoral products. In addition, these results helped to incorporate an understanding of the production of building materials. The information derived from the geological dataset are a complex feature and when relating it the ancient agronomists it is sometimes vague. Columella provides some details for viticulture, indicating clay could be used (4.33.1) and that terrain with sandy, or majority gravel are ill-advised (4.22.8). Then reviewing the geology of the selected villas there is a large variation of what is present for each site (Table 4.4). It is also important to note while this application is using modern geological data, is anticipated that it is unlikely within the time period for the underlying geology to have changed significantly and can be used to understand the reasoning why the villas were situated in that location.

Both Goodchild (2007) and Viitanen (2010) categorize geological characteristics based on what are favourable, unfavourable and bad for agricultural activities. Goodchild focuses on the suitability of agropastoral production, while Viitanen additionally focuses on the placement of a villa near building resources. Goodchild, therefore, will be used more frequently comparing my results. To create this ranking Goodchild and Viitanen's results from their geological analysis were used to form the ratings of geological/soil types (refer to Table 4.3).

Goodchild			Viitanen		
Favourable	Unfavourable	Bad	Favourable	Unfavourable	Bad
Volcanic sediments	Clay	Limestone	Volcanic soils	Clay	Limestone
	Alluvial sediments	Sands		Flysch (sedimentary deposit consisting of shale or marl)	
		Conglomerates		Alluvial soils	

Table 4.3: This table shows the main geological characteristics found in Goodchild and Viitanen's work.

One way to organize what could be produced on the villa sites is by providing a ranking of favourable, unfavourable or bad based on the geological/soil deposits found on each site. The ranking was based on whether these geological/ soil deposits were compatible with agricultural production. Both favourable and unfavourable shows that production can occur. Unfavorable is labeled more to show growth can occur but will not necessarily be the best soils that provide yield or support agricultural growth or be a place for animals. Bad shows that the geological/soil types aren't suitable and wouldn't be sought after feature when looking at a villa's placement. To create this ranking Goodchild and Viitanen's results from their geological analysis were used to form the ratings of geological/ soil types (refer to Table 4.3).

Ten villas fall under the unfavorable area of production, eight fall under bad areas for agricultural production, two are unknown and four fall into more of building materials than agropastoral production. Though 10 villas falls are located within what are defined as a poor area for agriculture according to Goodchild and Viitanen's results, limestone areas were known to be useful for pastoral or forestry ventures (Goodchild, 2007). The conglomerate section will likely cause eventual erosion, sand drains quickly, and clay requires a lot of effort to be workable (Goodchild, 2007). For travertine and tuff, Viitanen's (2010) work indicates that travertine and tuff were good for construction and close proximity to the villa site made access for blocks to be made near the villa site. In addition, travertine and limestone are materials that potentially may be used for making lime (lime being used for making plaster and mortar) (Viitanen, 2010). Lastly, the villas Santa Maria Legarano and Villa Cottanello fall into none of the listed geological fields.

OBJECTID	Site Name	Superficial Geology	Agriculture potential
1	Villa of Titus	Gravel/Sand/Clay	Unfavourable
2	Villa di Orazio	Marl/Limestone Marl/ Clay Marl	Unfavourable
3	Grotti di Torri	Sand/sandstone	Bad
4	Monte Calvo, Scandriglia	Gravel/ Conglomerate	Bad
5	Villa di Lucilla	Conglomerate	Bad
6	Poggio Catino	Limestone	Bad
7	Villa Vacone	Limestone/ Marly Limestone	Bad
8	Ponte Capo d'Acqua	Gravel/Sand/Clay	Unfavourable
9	Villa di Assio	Conglomerate/Limestone	Build
10	Villa Baciletti	Travertine	Build
11	Villa Volusii	Travertine	Build
12	Villa Monte Elci	Gravel/Conglomerate	Bad
13	Villa S. Lucia	Reworked Conglomerate/Sand/Volcanites	Bad
14	Villa S. Maria Assunta	Clay	Unfavourable
15	Villa Colli Rotti	Clay	Unfavourable
16	Villa S. Adamo	Clay	Unfavourable
17	Villa Terme Silla	Gravel/Conglomerate	Bad
18	Villa Paranzano	Clay	Unfavourable
19	Villa S. Vito	Clay	Unfavourable
20	Villa Colle Tulliano	Clay	Unfavourable
21	Villa Foglia	Tuff/Tuffite	Build
22	Santa Maria Legarano	Breach	N/A
23	Villa Cottanello	Marl/Cacarmite	N/A
24	Villa Grignano	Clay	Unfavourable

Table 4.4: The table provides the geological information for each villa[7]. Assessments are based on Table 4.3 which measure how certain geological characteristics are favourable, unfavourable and bad.

[7] The dataset for the geology derived from *Carta geologica 1:25.000* on https://geoportale.regione.lazio.it/documents/175

4.2 Distance accumulation and optimal paths

To answer the second question, a distance accumulation raster was used to create optimal paths within ArcGIS Pro. The optimal paths were determined based on the amount of energy required to travel across the landscape. An optimal path was defined as requiring the least amount of energy when travelling to a specific location. This section examines the potential paths originating from the Villa di Tito and its connectivity to the rest of the central Italian peninsula.

The initial distance accumulation results (Figure 4.6) provide insights into the potential paths within the Velino Valley and the Rieti Basin. Using just the slope barrier for creating a distance accumulation it shows that the Velino Valley was very accessible due to the flat terrain. Moving out of the Velino Valley into the Rieti Basin a colour change is notable, indicating that additional energy is required to travel across the landscape. The western portion of the basin was more difficult to travel due to the Velino River passing through the basin. The distance accumulation initially limited travel because of the river in the Rieti Basin but in reality, the river could be crossed. When only the slope barriers on the site are used, basic information about energy expenditure within the valley are provided. The methodology showed promising results but further manipulations in ArcGIS Pro were needed. This was due to the distance accumulation only being within the Rieti Basin and Velino Valley instead of the distance accumulation being spread outside these areas and being open to the entirety of the Sabine Region. The slope raster was manipulated by manually editing in line paths. There were four-line paths created to help break down the slope barriers.[8] The first were manual breaks I made to allow site points located in the slope barrier path to be connected to the flatter terrain. The second was the incorporation of

[8] All path lines were created then converted into a raster layer. At this point these features were merged together and nulled within the slope barrier raster.

lines to represent bridges present on rivers, which allowed for clear passage over waterways.[9] The third was adding the Roman roads to allow know paths to be incorporated and allow for additional cells on the flatter terrain to be nulled.[10] The final paths added were paths georeferenced from an 1808 map found in Lorenzetti's book. The map portrayed path lines through the Velino Valley as well as paths found in the southern mountains of the valley. The goal for this addition is to show whether these paths are efficient. The line paths were needed to expand the accessibility of the landscape to allow proper pathways to all sample towns, cities, and stations.

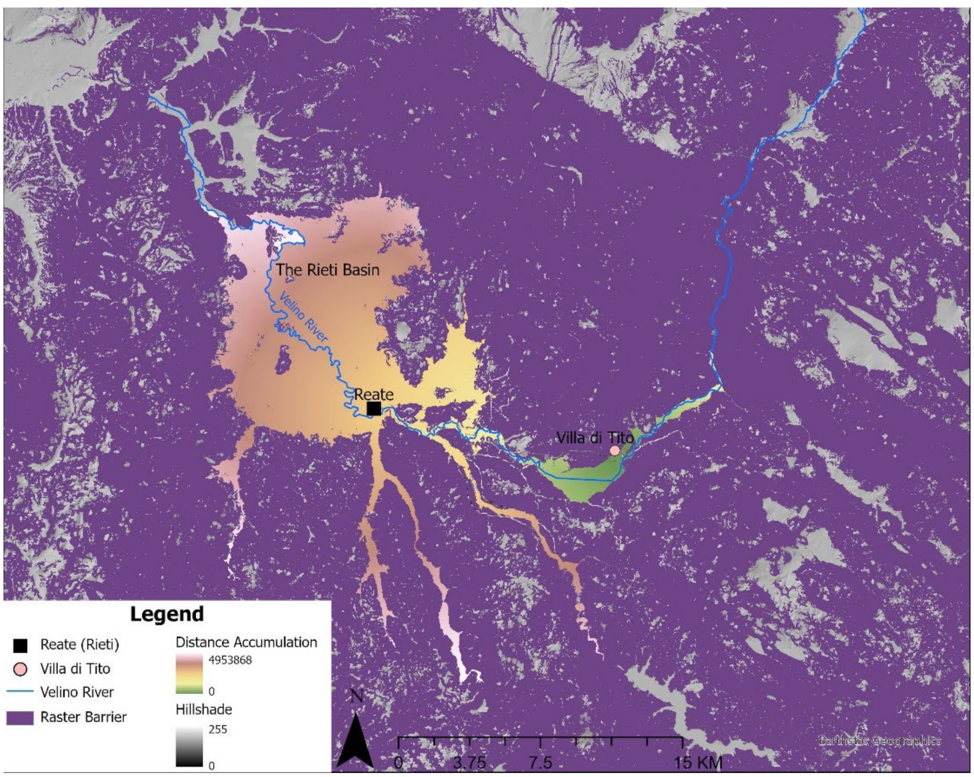

Figure 4.6: This is the first pass of a distance accumulation with a slope raster barrier. It provides insight in the limitations a barrier can have with minimal knowledge of paths and features within the landscape.

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[9] Bridge points were found on the website titled *The Digital Atlas of the Roman Empire* and then created as polylines in ArcGIS Pro using the create polyline features.
[10] The Roman roads were derived from a shapefile created by M McCormick. There were modifications made along the Via Salaria by me based on guide of the road written in Simone Nardelli's book *Sabina Archeologica: Itinerari Archeologici lungo la Via Salaria.*

By incorporating the additional line path, the amount of energy required for travelling changed from just the Rieti Basin and Velino Valley to the entire Sabine region. The landscape that was navigable became easier to travel through and required less energy. The distance accumulation allows more travel options through the Apennines (Figure 4.7), and it begins to show many areas that are easier to navigate then others. To begin, the Velino Valley and the Rieti Basin were the most efficient areas for travelling. When paths and bridges were added to the slope barrier, an ancient bridge (*Ponte Romano*), in the town of *Reate* (modern Rieti) opened the accessibility of the Rieti Basin. When comparing the previous distance accumulation in the basin, the known sites and cultural modifications influenced the accessibility of the villa to the other sites.

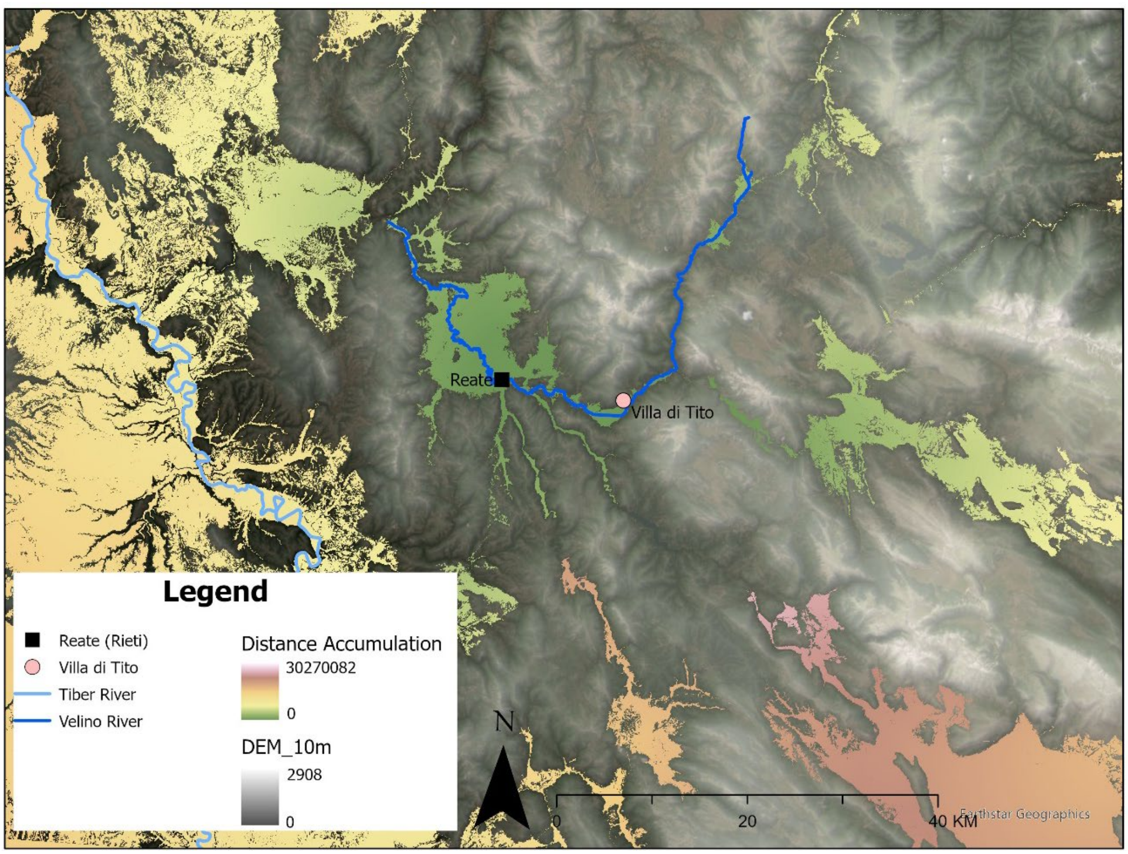


Figure 4.7: This map shows the new distance accumulation raster which indicates that much of central Italy within Sabine Territory and the central Apennines were within easy reach of the Villa di Tito. The blue lines represent rivers found within the landscape of the study area.

From the final distance accumulation seen in Figure 4.7, optimal paths were created to see efficient paths from the Villa di Tito to cities, road stations and towns (Figures 4.8). The villa reaches 80% of cities, 80% of towns and 66.6% of road stations based on the sample sites within the Sabine region. This indicates that these sites were easier to access and would be easiest to travel to with products. One of the towns in the south of the Velino Valley was not reachable. Even applying the paths from an 1808 map in Lorenzetti's book did not allow for easy access to the south of the valley. The second feature to note is there are many waterways in the region that could potentially obstruct a path from forming. It was clear in this circumstance that it was more efficient to travel though the flatter terrain than trying to go over steeper terrain. The area was known for travel through the mountainous terrain for herding but, it is worth noting that the variables used for creating these paths were specifically for transport in relation to carts, loaded mules, travelling with herd and/or travelling by foot. So, herding is included in this variable, but the paths are created with the mindset of carts travelling with goods. Another interesting result is the Roman road itself. The Optimal Paths closely follow the Via Salaria and began to branch away from the roads within the Rieti Basin, which was clarified further when looking at the history of the basin. The deviation from the Roman roads can also be found in the southeast paths towards the city of *Nersae* and the town *Colle Civita* (refer to Appendix D for the city and town's locations on a map).

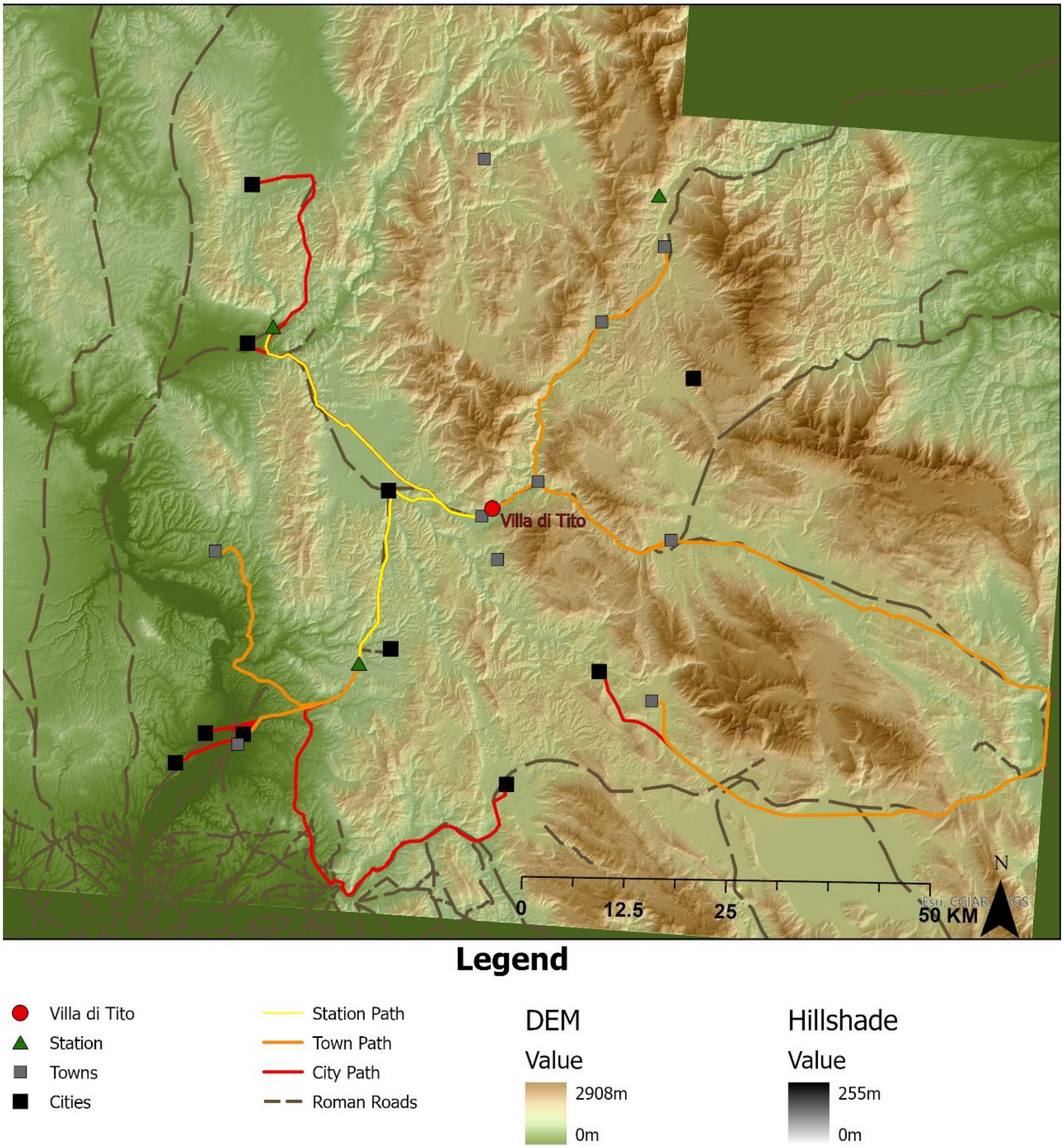


Figure 4.8: This map shows all optimal paths as a line created in ArcGIS Pro. It also overlaps the known Roman roads in the study as well as all the points where the optimal paths connect the Villa di Tito. Appendix D contains separate visuals for the optimal paths going to the cities, towns and road stations.

Chapter 5: Discussion and Conclusions

This discussion is divided into two sections each addressing one of the two main research questions posed in this thesis. The first is the physical placement of the Villa di Tito within the Velino Valley compared to the rest of the sample villas within the Sabina. The Villa di Tito was found to be unique when compared to the first of the sample villas. It occupied a prominent geographical location and although it was underlain by unfavourable soil conditions for agriculture, the consistent year-round solar energy provided conditions amenable to agricultural activities. Given the prominence of the Villa di Tito compared to the rest of the Sabine villas, an alternative hypothesis is proposed. Least cost paths created using various contemporary datasets that helped establish how well connected the Villa di Tito was to the surrounding cities, towns and road stations in the Sabine region based on contemporary datasets applied. The paths established were in close proximity the ancient Via Salaria and provides further evidence for the villa's location within the regional landscape. The discussion concludes exploring the merits and challenges of applying geographical information systems such as ArcGIS Pro to archaeological research.

5.1 Comparing the Villa di Tito's placement in the Landscape.

5.1.1 Comparing the Sample villas and Literature to the Villa di Tito.

The goals of this research were to understand the Villa di Tito' placement through an economic, environmental and cultural lens. This research showed that the sample villas shared common characteristics to Roman villas in Italy studied by Goodchild (2007) and Viitanen (2010). They used similar datasets for their research in different geographical areas, with Goodchild focusing on the Tiber Region and Viitanen on the Roman Campagna. My conclusions, with respect to the variables slope, aspect, geology and sunlight are the same as Goodchild's. The data also correlates with what the ancient authors have to sat about villa placement and the economic exploitation of the countryside. Goodchild used the ancient authors suggestions for the creation of their predictive models. Goodchild's (2007) study area was also in the province of Lazio and was directly on the other side of the Tiber River to the west, which may be why the results were so similar. Knowing the history of the landscape is important because it brings context to the features applied to the sample villas. Based on the similarities of how these features are important for villa placement, it also provides evidence showing the Villa di Tito was uniquely placed within the villa samples. Additionally, the sample villas as a whole show little to no exact pattern of a villa's placement in the landscape. This further reinforce that a villas placement is heavily influenced on the local context. The Villa di Tito was placed on the highest elevation, slope and orientated in a south-east cardinal direction. Though the villa's placement is unique, there was a potential for production on the landscape. This can be presented through the historical, economic and cultural knowledge of the Sabine region.

Historically, the primary sources describe the beneficial characteristics on the landscape that are the most useful for grains, vineyards and olives. Each plant has a variation for what would work best for each plant type. This is useful because it brings a better understanding of whether certain plants were more beneficial within the Sabine region. For grains there was a peculiar placement needed for growth. A requirement that was referenced was that they should be grown on plains and not steep locations (Columella 1.2.4, 2.9.3; Varro 1.6.5). When discussing potential soils that can be useful Columella (2.9.12) gives a clear remark on how grains can be grown in gravelly ground and sand. The recommendations for growth of vineyards was that they should be located on hills and have them facing a North or Southern direction (Columella 3.2.6). Similar to grains, Columella adds that the incorporation of clay to gravelly dirt or adding gravel for clayey soil will be good for both grains and vineyard growth (Columella 2.15.4). Lastly when discussing olives, the primary sources detail where olive types could grow in different conditions. Both Cato (6.2) and Varro (1.24.1) reference that Licinian olives should be planted in colder and thinner soil. Later Cato adds a general statement that olives (among other plants) should be planted in rich humid ground (Cato 4.1). So, depending on the landscape the conditions for olive can thrive in varying circumstances. One commonality within the primary sources in the placement of olive growth is to be planted facing west towards the sun (Cato 6.2; Varro 1.24.6).

From the primary sources, additional information was given by Goodchild (2007) and Viitanen (2010) relating to cardinal direction. The cardinal direction was something to note within the placement of plants in the primary sources, but it was often not fully explained. The cardinal directions were briefly described for villa placements by showing temperature control (Columella 1.5.8; Varro 1.12.1). With this in mind by incorporating Goodchild and Viitanen's thoughts it can be thought to be something similar for the plants and villa placements. Viitanen (2010) reiterates this in her work by mentioning the house facing north was useful for warmer climates and south for cooler climates. Goodchild (2007) also mentions the risk of winds and sunlight coverage were factors that were considered for the placement of plant growth and determines that the southeast and east direction was more beneficial then north and western directions. The knowledge of the primary source's stance on specific growth for certain plants is helpful to distinguish the production potential for villas. When relating to the Villa di Tito, the results and multiple references of olive and herding found within the Sabine region helped reiterate that olives would have been the more practical plant to be grown compared to grains and vineyards.

Economically, there was potential within the Sabine region for both herding and oleoculture. Though 41% of the sample villas are under unfavourable soil conditions the ancient sources do comment that olive growth is possible. Also, the sample villa's location were under constant sunlight provides an additional characteristic needed to support agricultural ventures. With the sunlight present and the presence of potential production in the soils combined, the villas could have a more reliable area for growing. Cato (6.1-2) provides more detail on how the planting success of olives is dependant on the location but was very adaptable on the landscape. The variations that are considered are the soil types, and whether they are on a hill slope or flatter terrain. Goodchild (2007) also mentions that olives are the most resistant of crops to the weather and could be a reason for its predominance in the Sabine region. The soils in the Sabine regions (clay, sands and conglomerates) were difficult for plant growth and being difficult to plough (Walker, 1967). Though they were difficult the clay was a soil that could be manipulated for many agricultural ventures. Grains and grapes were prominent in other areas of central Italy because they were not as versatile within the landscape of the Sabine region. Based on the location of the Villa di Tito it is likely the site may have participated olive production due to these products being known in the region.

Within the Sabine region the historical evidence clearly indicates that herding was practiced. Varro (2.1.16) provides an excellent overview of the long-distance seasonal transhumance in Italy, which includes the Velino valley and the Reatine plain where the city of *Reate* (Rieti) is located. His example is the herding of animals between his estates in the Apulia and the Rieti Basin during the summer months. It is challenging to accurately estimate the production potential considering there is variation in scale between animal and the socio-economic standing of the herder but there was (and still in modern times) a presence of localized transhumance in the landscape.

A final component for understanding a villa's placement and production potential is the site's proximity to roads and bodies of water (both navigation and habitation). The villas' proximity to Roman roadways and water sources was important according to the primary sources. It was also an important factor in Goodchild's (2007) models for economic production. Viitanen (2010) also notes the importance of waterways and water sources in their study. Through having an idea of the importance of water courses, waterways and roadways are for villas, all the villa samples were analyzed to see how far away they site were. This was completed through buffering by a kilometer interval. This showed all villas were situated within 1km from a watercourse. From the sample villas ten are within 2 km of roads and the rest of the villas (fourteen) were found to be over 2km away from a Roman Road. The villa over 2km away from roads are all located in the flatter terrain of Tiberine Sabina. The fourteen villas are surrounded by both the Via Flaminia and Salaria, they were still accessible due to the flatter terrain. From these key features and all the sample villas this is the key advice from the ancient agronomists that was followed.

I would argue that the economic and cultural spheres overlap when analyzing the Villa di Tito because the area was historically known as a center of pastoralism and oleoculture. To continue in the economic sphere the Via Salaria was used and placed in the landscape where movement was prevalent prior to Roman settlement. Based on historical knowledge and practices of the Sabine people in the area, the Romans adapted the landscape in a way which continued production that was occurring in the area, which can be seen when comparing to other villas located in the Sabine region.

5.1.2 The Villa di Tito's Placement

Looking at the Villa di Tito's physical placement in the landscape can give additional insight to its placement within the landscape. One question that arose during this analysis on the Villa di Tito is why this site is positioned in higher values based on the datasets used for comparing the sample villas. As discussed in the previous section, the Villa di Tito was situated at the highest elevation, had the steepest slope and the villa follows the agronomist's recommendation of facing the south-east. The site was in a place known historically for agropastoral ventures. The variables of geology which shows unfavourable production potential and that the site contains consistent solar energy. These results demonstrate the merits of the placement of the villa but there is an additional inference to the Villa di Tito's placement within the Velino Valley.

In some respects, the Villa di Tito may have particular characteristics that closely resemble~~s~~ maritime rather than rustic villas. Marzano (2007) and Witcher (2020) both define the maritime villa complex as a symbol of extravagance which is placed in a scenic location overlooking the sea and surrounding landscape. When comparing rustic and maritime villa types, Marzano (2007) also describes maritime villas as "a symbol of extravagance, even debauchery, in contrast to the villa rustic, which with its involvement in agriculture, is represented as an appropriate economic enterprise for a member of the elite" (2007, p.11).

There are two additional villas (the Villa at Vacone and the Villa at Monte Elci) that are like the Villa di Tito, as they are also a monumental terrace villa overlooking the landscape, in which they were situated. Villa Monte Elci was a terraced villa measuring 70 x 70m (Marzano 2007; Witcher 2020) along with another terrace installed later on for pastures and situated in close proximity to local markets. The Villa at Vacone, which included an oil press, a terraced villa measuring 62m long and overlooking the hills and streambeds in the area (Franconi et al. 2019). Both sites are like the Villa di Tito because they have a notable presence within the landscape and can support productive ventures. The main differences between the sites are the platforms the villas rest on. The Villa at Vacone rests on two cryptoporticus's measuring 2.5m in height (Franconi et al., 2019) whereas the Villa di Tito rests on buttresses that are 11m in height and a cryptoporticus underneath that is 11m tall. The height of the Villa di Tito creates a more imposing feature within the landscape. Based on these observations, it is clear the monumental aspect of even rustic villas need to be taken into consideration when studying their relationship to the landscape. These villa sites are constructed to be seen and not just to produce goods to sell to market.

The Villa di Tito's size and construction shows that the site is extravagant. Through architectural evidence, the rooms were large and there was an additional room added on during the primary phase of occupation (McCallum et al., 2019). Room 10, measuring 5.5 x 5.3m, was different from others and was built using a different masonry style compared to the rest of the rooms. Room 10 also contained the remains of a vaulted ceiling and a semi-circular niche on the back wall (Figure 5.1). McCallum et al. (2019) remarks that the construction was similar to public buildings in an urban setting, such as Pompeii. The Villa di Tito also contains a large terracing wall against which the rooms were placed against. Compared to the other villas, Villa Monte Elci was built with multiple retaining walls (Marzano 2007) and Villa Vacone like the Villa di Tito was on one terrace. The only difference is that the shape of the villa is more of an L or U shape villa compared to the Villa di Tito which aligns with the mountain in a straight line. So even with a similar building technique, each site conformed to the natural terrace on which it was situated.

Figure 5.1: Drone shot was taken on the 2022 field school. The room is located on the western end of the site terrace.

Maritime villas also typically have commanding views of their surroundings. Villa di Tito is positioned to have a view that encompasses the entire valley. In a modern context when travelling by train from Rieti towards the Castel Sant'Angelo station you can easily see the villa nested in the hillside. This shows that the site could have been easily seen in the valley. Witcher (2020) remarks other villas on a lakeshore are similarly situated like coastlines and uses the examples of Lakes Martignano and Bracciano located in the Tiber Valley. This is comparable to the Villa di Tito because of its placement overlooking *Lacus Cutiliae* (Lago Di Paterno) (refer to Figure 2.4). As previously mentioned, this lake was historically noted to be the "navel" of central Italy and was known for its connection to the Sabine goddess Vacuna.

The Sabine region was a well-known area and plenty of notable people from the past were from the region. Varro had family ties in the region and owned a property near Rieti. The Flavian dynasty which ruled Rome from 69 to 96 C.E was known to have ties to the area. The Flavians would frequently reference their Sabine origins, which appears to have been a part of the family's identity and indicates a deep connection to the area. This makes sense considering the initial belief of the Villa di Tito is that it is an imperial villa owned by the Flavians. This caused the villa to adopt the name Villa di Tito after the emperor Titus and there are multiple archaeological sites in the region that have been tied to this family (ex. Baths of Vespasian and Nymphaeum Flavians). Knowing the personal connections of the area is useful because it incorporates the historical narrative found in the region. Though this is the narrative, as mentioned in the introduction of the site the villa is not confirmed to be owned by the Flavians due to lack of physical evidence but further excavation in the future could help uncover the owners of this villa.

5.2 The connectivity of the Villa di Tito and comparing the Optimal paths to the Via Salaria

Moving from villa placement to distance accumulation, it is possible to get some idea of the Villa di Tito's connectivity to other settlements in the landscape during the Roman period. From the sites selected it can be noted that the Villa di Tito is a place that is well connected. Being near the Via Salaria, the road would have been the main route for travel from the villa to the majority of the sample sites chosen for this research. This supports the economic viewpoint of the villa because it has places to send products to multiple markets within the Sabine region. The connectivity was found in the results, but the historical knowledge of the landscape helped build the efficiency of the Villa di Tito's connectivity. The historic landscape of the Velino Valley and Rieti Basin helps further explain that optimal path's placement as well as the Via Salaria. Waterways and lakes within the landscape make it more difficult to navigate if only travel by land is considered.

Another feature included for the creation of the optimal paths were paths found within the mountains. The paths were from the 1808 map found in Roberto Lorenzetti's book *Dal Velino alla Cascata delle Marmore: uomini, aque architetti, bonfiche e grandi interessi tra Rieti e Terni dall'epoca romana al'900.* These path additions did not have an impact on the generated optimal paths, and none crossed over the mountainous terrain (refer to Section 4.6). The attempt to incorporate hillier paths from the 1808 map were not more efficient based on the results It could be considered a shorter route but, it was not more cost effective compared to travel across the flatter terrain. The lack of paths with this route could have been due to error or that these paths cost more energy. Within the contemporary context when speaking to the locals the farms still use paths in the mountains for herding their animals, which they move to different pastures for the summer. The consistent use of these paths demonstrate their usefulness within the immediate context but when moving across the broader landscape of the Sabine region, but these paths did not connect the villa to regional towns, cities or road stations.

The modelled optimal paths in the Velino Valley closely followed the Roman roads within it. The most efficient paths follow the northern position in the flatter terrain of the valley (refer to Figure 5.2). The optimal path overlaps with the Via Salaria upon entering the Velino Valley but when entering the Valley through the Rieti Basin the paths diverge. The divergence is the optimal path crosses over the Velino River. The realistic path used for travelling would not cross over a river at multiple points like the optimal path portrays but, it would cross once or completely avoid the river. This part of the optimal paths compared to the Via Salaria do not match and in this instance the road is the more efficient path when entering the valley. Furthermore, the river displayed is in the contemporary context. In the past the valley often flooded from the river and contained swampy patches (Lorenzetti, 2021). There were interventions to limit the flooding dating from Roman times all the way to the 1930's in which the current river flow is what you can see in all the maps. Given the history of the river's recurring flooding it builds on to the reasoning to why the Via Salaria is located higher up in the valley.

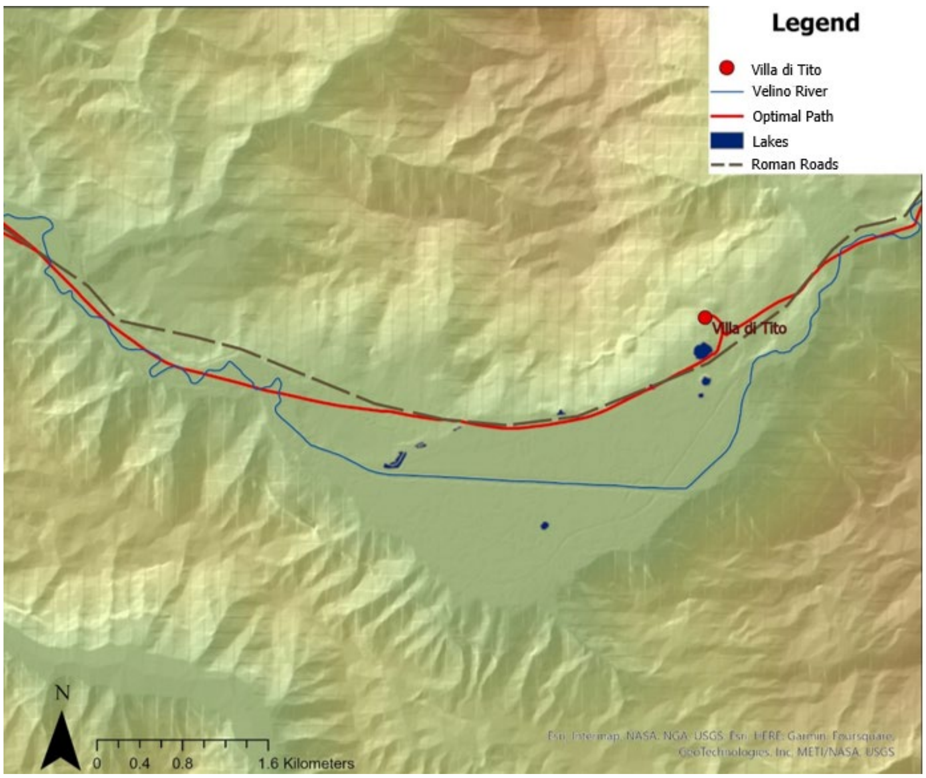


Figure 5.2: This is a zoomed in version of the Velino valley. It gives a clear image of where the optimal paths and Via Salaria overlap within the landscape.

In the Rieti Basin, there is a divergence on what is efficient and what is present within the landscape. Within the basin you can see the optimal paths cross more centrally compared to where the Via Salaria is located (refer to Figure 5.3). There are two main reasons for the optimal path not being efficient and why the Via Salaria was more fitting. This is based on the historic landscape and how the drove roads in the area were impacting the road's placement because these paths were in use for centuries prior to the placement of the Via Salaria. To the east of the optimal path there are two lakes within the modern landscape. In the past, this area as well as the Rieti Basin contained a lake known as *Lacus Velinus* which influenced settlement in the basin (Betori et al., 2021) (Figure 2.3). Flooding during the prehistoric period likely influenced the movement of people across the basin.

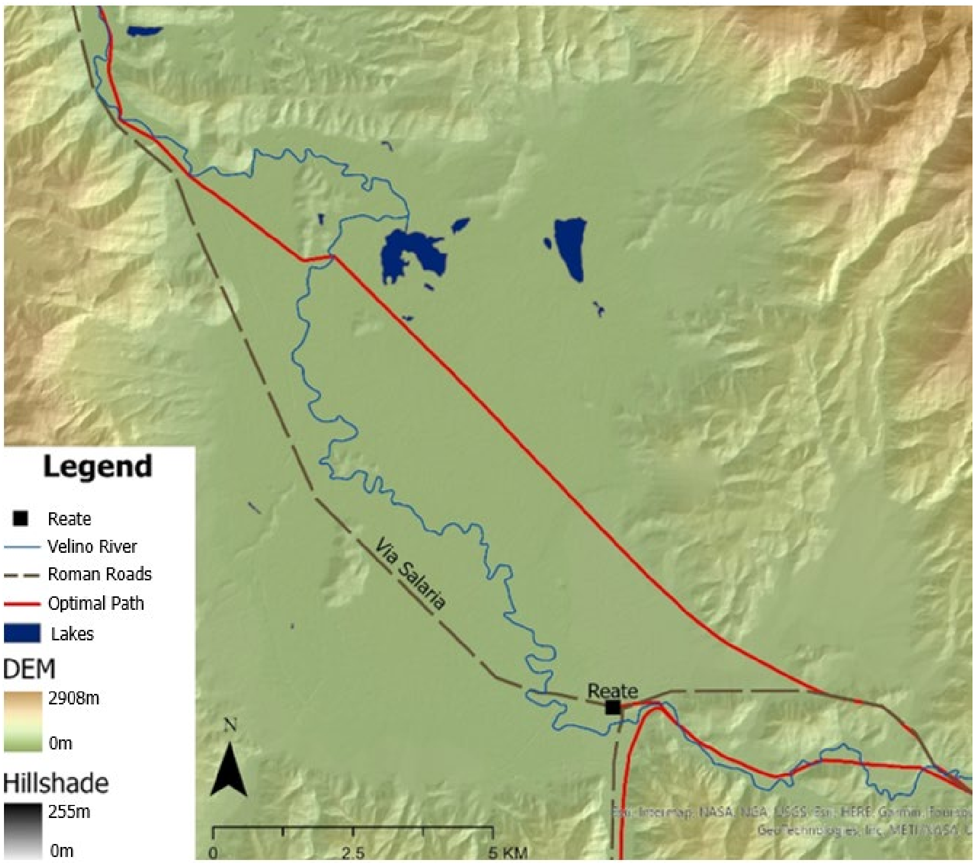


Figure 5.3: The image to the left is of the optimal paths as a line which crosses through the Rieti Basin in relation to where the Via Salaria is located.

The landscape was known to be swampy due to the lack of consistent water flow (Betori et al., 2021). The literary sources (Pliny 3.17.38) mention that a channel was cut in the ground to allow water to flow out of the basin into the *Cascate Delle Marmore* (modern Mamore Falls) and this caused the water to recede. At this point, the Via Salaria was created and the land that was drained became suitable for agropastoral activities. This leads into the second reason to why the

Via Salaria was placed in the landscape. When situating the Via Salaria, it was known that the road follows past drove roads used for travel and herding within the basin. The drove roads date as far back to the Italian Bronze Age (13th century B.C.E) and there is archaeological evidence connecting the drove roads to the late Bronze Age and early Iron age (12-9 B.C.E) (Coarelli, 1988). By having a well-established pathway, it was efficient to construct the road on a known route. Having an efficient route within the Rieti Basin and Velino Valley helped show that the roadway was a route to connect the Villa di Tito to cities, towns and road stations (Figure 4.8).

5.3 Application of GIS to Roman Archaeology

When attempting to answer my research questions, ArcGIS Pro was a useful tool but there were also issues with the application. This thesis applies two methods that give more insight into how complex archaeological sites can be to quantify spatial connections based on spatial characteristics. For the first question ArcGIS Pro was useful due to its capability of extracting specific values for each sample villa. One problem that can arise when using this application is that the sites could have a slight variation in values depending on where the x and y coordinates used for the site point are placed. This would impact the more detailed values like elevation, slope and aspect. Though for this research the DEM raster used were at a 10m cell size, so it didn't affect too much but the smaller the cell size the higher chance there would be more variation found for extracting values, therefore the resolution used matters when doing this analysis. Geology and solar radiation are more general with their raster values, so it isn't as problematic. A solution would be to create an average based on multiple coordinates for each site. Overall, though the specific point was useful because it gave a basis of being able to create a database of features that could be compared and discover any patterns within the values. The reality of the results is there wasn't as many notable patterns found when comparing to the other sites. It is catered to their specific location instead of just solely relying on the recommendations written by the ancient agronomists.

The use of optimal paths created valuable insight for the Villa di Tito. First, it is clear that the application of the equation by Pandolf et al. (1977) to the data is useful. It can be adjusted to accommodate to local conditions, which is helpful for research in any geographical setting including our study area. With additional evidence domestic herd animals were prevalent in the Velino Valley the equation's values can be adjusted, furthering the historical narrative of the area. The equation used allows for the variable to be interchangeable which can be helpful for modify carrying weights or the modes of transportation that can be relevant within a study area. The first can be providing additional barriers and navigable waterways to it. The second is with additional fauna evidence found in the 2022 excavations adjustments can be made. This then could build a model similar to Goodchild to look at specific locations in the Velino Valley that could support specific plant growth.

Lastly the optimal paths provided insight into the route of the Via Salaria's placement in the landscape that allowed the villa to connect to other sites. The landscape of the Basin and valley were exposed to significant flooding and marshlands. Having this type of landscape in mind, the Via Salaria was placed in an optimal location to avoid the consistent flooding of the flatter terrain. For the Rieti Basin, the optimal paths show a limiting factor because the paths were in a location that was continually flooded so it would not be useful for travelling. The Via Salaria was situated in an area in the basin that was not a heavy flooded. The placement of the Via Salaria within the basin was helpful in showing the limitations of the optimal paths. The historical knowledge of the landscape is an important factor to consider when interpreting the historical landscape and archaeological sites.

5.4 Conclusions

When beginning this thesis, the goal was to understand the placement and connectivity of the Villa di Tito by applying spatial connections. There were three key take aways from this thesis. Putting the villa in context with respect to the sample villas within the region was useful in relation to the Villa di Tito's placement in the Velino Valley. Aside from the Villa di Tito's production potential, the site is different from the sample villas in the Sabine region. By applying the maritime villa type it provides insight on to why the Villa di Tito was placed in a prominent location in the Velino Valley. The next point in this thesis began as something to show connectivity of the Villa di Tito to other sites in the Sabine Region. By doing this it helped provide examples of the potential sites efficiently travel to and from the villa. It also helped understand that the Via Salaria was efficiently placed in the Rieti Basin and Velino Valley. This research also demonstrated the value of incorporating ArcGIS Pro to research on archaeological sites. This means that applying GIS applications is useful but to gain a wholistic interpretation you cannot solely rely on GIS results but interconnect it with the historical knowledge of your work.

The Villa di Tito is an interesting case because in many ways it is unique when compared to other villas within the region. The Villa di Tito was a prominent place and was used for production, especially because it is so central to the Via Salaria which connects the two sides of the Peninsula. The villa's size and position can be compared to the typical features of the maritime villa subtype. Incorporating the history of the area and literature it shows that the site could support production, but it also has a symbolic component. This thesis helps show that the typical subtypes used for villa analysis are more fluid than what was initially believed. Quantifying characteristics of the 24 villas found in the Sabine region, show that there is not a consistent way of placing a villa in the rural landscape. The villas also do not follow directly what the ancient agronomists recommend. There are limiting patterns presented in the characteristics used for this thesis, but aspect, slope and solar radiation were the features with the greatest influence on the villa's placement. This also can be said for the creation of the optimal paths. The paths showed the most interesting because the paths created can be compared to how close or far away, they were placed in the Via Salaria and how connected the Villa di Tito is to multiple archaeological sites in the Sabine region.

The optimal paths helped show that there needs to be a balance of historical knowledge of the landscape and what is being made in ArcGIS Pro. When looking specifically at this study area the optimal paths confirmed optimal pathways of travel to the other sites but something interesting also came from the results. By incorporating the historical knowledge of the landscape, the optimal paths further confirmed the Via Salaria's placement on the landscape and how it was an efficient piece of transportation infrastructure during the Roman period. The paths help provide further insight on how ArcGIS Pro is useful for research, but it only tells a partial story and without the incorporation of the historical and archaeological evidence the results of this section would not have the holistic approach needed for answer questions about the past.

The Villa di Tito site created a baseline of interpretations that connect the site to its immediate landscape and through the Sabine region. In the future more datasets and variables can be added to create additional interpretations. For understanding the Villa di Tito's placement there was a limited selection of environmental components used which helped with defining the production potential of the site. Adding more climate datasets and floral and faunal evidence could build a stronger reasoning for the placement and production potential of a villa within the Sabine region. Additionally, predictive modelling could further draw connections to where agropastoral production could have occurred on and around the Villa di Tito. Further edits can be made to the optimal path model. This can vary from incorporating water travel or modify the equation to cater to other forms of travel. From this research, GIS is a useful program when interpretating archaeological sites and was helpful in displaying the unique placement of the Villa di Tito in the Velino Valley.

Appendices

Appendix A: Villa Sample in the Sabine Territory

The table below is all the sample villas applied in question 1. It has each villa with their natural features that was compared in this thesis. The features were pulled from ArcGIS Pro using point value geoprocessing tool.

ID	Site Name	Elevation (m)	Slope (degree)	Aspect	Cardinal direction	Geology Type	Solar Radiation Summer (Wh·m^{-2})	Solar Radiation Fall (Wh·m^{-2})	Solar Radiation Winter (Wh·m^{-2})	Solar Radiation Spring (Wh·m^{-2})
1	Villa di Tito	503	24.28	142.63	SE	Gravel/ Sand/Clay	$4.91 x10^5$	$2.45 x10^5$	$1.34 x10^5$	$4.18 x10^5$
2	Villa di Orazio	393	2.13	62.1	NE	Marl /Limestone/ Clay Marl	$4.86 x10^5$	$1.84 x10^5$	$8.68 x10^4$	$3.78 x10^5$
3	Grotti di Torri	159	3.01	160.01	S	Sand/ Sandstone	$4.89 x10^5$	$1.97 x10^5$	$9.66 x10^4$	$3.87 x10^5$
4	Monte Calvo	379	5.7	268.57	W	Gravel/ Conglomerate	$4.90 x10^5$	$1.92 x10^5$	$9.25 x10^4$	$3.84 x10^5$
5	Villa di Lucilla	405	12.26	235.98	SW	Conglomerate	$4.93 x10^5$	$1.92 x10^5$	$9.22 x10^4$	$3.86 x10^5$
6	Poggio Catino	384	16.22	101.68	E	Limestone	$4.78 x10^5$	$1.97 x10^5$	$9.78 x10^4$	$3.81 x10^5$
7	Villa Vacone	388	16.25	147.45	SE	Limestone/ Marly Limestone	$5.08 x10^5$	$2.29 x10^5$	$1.20 x10^5$	$4.17 x10^5$
8	Ponte Capo d'Acqua	376	2.69	223.52	SW	Gravel/ Sand/Clay	$4.96 x10^5$	$1.97 x10^5$	$9.61 x10^4$	$3.91 x10^5$
9	Villa di Assio	408	9.64	167.22	S	Conglomerate / Limestone	$5.10 x10^5$	$2.26 x10^5$	$1.17 x10^5$	$4.16 x10^5$
10	Villa Baciletti	71	3.01	69.97	E	Travertine	$4.78 x10^5$	$1.85 x10^5$	$8.82 x10^4$	$3.74 x10^5$
11	Villa Volusii	48	4.26	151.8	SE	Travertine	$4.84 x10^5$	$1.94 x10^5$	$9.46 x10^4$	$3.82 x10^5$
12	Villa monte Elci	310	15.99	322.96	NW	Gravel/ Conglomerate	$4.65 x10^5$	$1.67 x10^5$	$7.58 x10^4$	$3.56 x10^5$
13	Villa S. Lucia	299	12.22	245.89	SW	Reworked Conglomerate /Sand/ Volcanites	$4.94 x10^5$	$2.06 x10^5$	$1.03 x10^5$	$3.96 x10^5$
14	Villa S. Maria Assunta	131	17.08	75.86	E	Clay	$4.57 x10^5$	$1.69 x10^5$	$7.83 x10^4$	$3.52 x10^5$
15	Villa Colle Rotti	126	8.98	159.97	S	Clay	$4.93 x10^5$	$2.07 x10^5$	$1.03 x10^5$	$3.95 x10^5$
16	Villa S. Adamo	110	3.92	192.43	S	Clay	$4.88 x10^5$	$1.99 x10^5$	$9.82 x10^4$	$3.88 x10^5$
17	Villa Terme Silla	286	8.16	232.89	SW	Gravel/ Conglomerate	$4.97 x10^5$	$2.11 x10^5$	$1.07 x10^5$	$4.00 x10^5$
18	Villa Paranzano	271	10.21	234.73	SW	Clay	$4.95 x10^5$	$2.06 x10^5$	$1.03 x10^5$	$3.96 x10^5$
19	Villa S. Vito	251	2.13	151.91	SE	Clay	$4.90 x10^5$	$1.94 x10^5$	$9.41 x10^4$	$3.86 x10^5$
20	Villa Colle Tulliano	272	2.69	313.4	NW	Clay	$4.86 x10^5$	$1.86 x10^5$	$8.87 x10^4$	$3.79 x10^5$
21	Villa Foglia	91	2.86	268.24	W	Tuff/Tuffite	$4.80 x10^5$	$1.87 x10^5$	$8.97 x10^4$	$3.76 x10^5$
22	Santa Maria Legarano	403	4.26	241.91	SW	Breach	$4.99 x10^5$	$2.00 x10^5$	$9.79 x10^4$	$3.94 x10^5$

23	Villa Cottanello	393	6.72	223.43	SW	Marl /Calcarenite	5.00×10^5	2.07×10^5	1.03×10^5	3.99×10^5
24	Villa Grignano	302	9.64	167.06	S	Clay	5.04×10^5	2.17×10^5	1.11×10^5	4.07×10^5

Appendix B: Archaeological Sites

This appendix contains all the archaeological site points that is used for the whole thesis. It gives a basic time of occupation, site type, coordinates (longitude and latitude) and what database or book they were collected from.

Site Name	Date in Use	Site Type	Longitude	Latitude	Source
Lucus Feronia	550B.C.E-640C.E	City	12.5969	42.1297	Åhlfeldt, J. (2015). *Digital Atlas of the Roman Empire.* Digital Atlas of the Roman Empire. https://imperium.ahlfeldt.se/
Nersae	30B.C.E-640C.E	City	13.1779	42.2083	Åhlfeldt, J. (2015). *Digital Atlas of the Roman Empire.* Digital Atlas of the Roman Empire. https://imperium.ahlfeldt.se/
Carisolo (Piano della Civita)	550 B.C.E-640 C.E	City	13.0443	42.0817	Åhlfeldt, J. (2015). *Digital Atlas of the Roman Empire.* Digital Atlas of the Roman Empire. https://imperium.ahlfeldt.se/
Trebula Mutuesca	330 B.C.E-640 C.E	City	12.8678	42.2281	Åhlfeldt, J. (2015). *Digital Atlas of the Roman Empire.* Digital Atlas of the Roman Empire. https://imperium.ahlfeldt.se/
Interamna Nahars	650B.C.E-640 C.E	City	12.6433	42.5604	Åhlfeldt, J. (2015). *Digital Atlas of the Roman Empire.* Digital Atlas of the Roman Empire. https://imperium.ahlfeldt.se/
Spoletium	300 B.C.E-640 C.E	City	12.7403	42.7353	Talbert, R. J. A., & Bagnall, R. S. (2000). *Barrington Atlas of the Greek and Roman world*. Princeton University Press
Amiternum	330B.C.E-640C.E	City	13.3088	42.402	Åhlfeldt, J. (2015). *Digital Atlas of the Roman Empire.* Digital Atlas of the Roman Empire. https://imperium.ahlfeldt.se/
Reate	550B.C.E-640C.E	City	12.8589	42.4020	Åhlfeldt, J. (2015). *Digital Atlas of the Roman Empire.* Digital Atlas of the Roman Empire. https://imperium.ahlfeldt.se/
Vacchereccia	30B.C.E-640C.E	City	12.5538	42.0961	Åhlfeldt, J. (2015). *Digital Atlas of the Roman Empire.* Digital Atlas of the Roman Empire. https://imperium.ahlfeldt.se/
Osteria Nuova	30B.C.E-640 C.E	Station	12.8215	42.2122	Åhlfeldt, J. (2015). *Digital Atlas of the Roman Empire.* Digital Atlas of the Roman Empire. https://imperium.ahlfeldt.se/
Tres Tabernae	---	Station	12.6807	42.5804	Åhlfeldt, J. (2015). *Digital Atlas of the Roman Empire.* Digital Atlas of the Roman Empire. https://imperium.ahlfeldt.se/
Tufi (Arquata del Tronto)	330C.E- 640 C.E	Station	13.2521	42.7353	Åhlfeldt, J. (2015). *Digital Atlas of the Roman Empire.* Digital Atlas of the Roman Empire. https://imperium.ahlfeldt.se/
Colle del Forno	750B.C.E-330C.E	Town	12.6453	42.1184	Åhlfeldt, J. (2015). *Digital Atlas of the Roman Empire.* Digital Atlas of the Roman Empire. https://imperium.ahlfeldt.se/
Colle Civita	300 B.C.E-300 C.E	Town	13.2567	42.1771	Åhlfeldt, J. (2015). *Digital Atlas of the Roman Empire.* Digital Atlas of the Roman Empire. https://imperium.ahlfeldt.se/
Forum Novum	30B.C.E-640 C.E	Town	12.6038	42.3306	Åhlfeldt, J. (2015). *Digital Atlas of the Roman Empire.* Digital Atlas of the Roman Empire. https://imperium.ahlfeldt.se/
Vespasiae	30B.C.E-200C.E	Town	12.9898	42.7698	Åhlfeldt, J. (2015). *Digital Atlas of the Roman Empire.* Digital Atlas of the Roman Empire. https://imperium.ahlfeldt.se/
Badies	30B.C.E-640 C.E	Town	13.2617	42.6777	Åhlfeldt, J. (2015). *Digital Atlas of the Roman Empire.* Digital Atlas of the Roman Empire. https://imperium.ahlfeldt.se/

Falacrinae	30B.C.E-640 C.E	Town	13.1706	42.5934	Åhlfeldt, J. (2015). *Digital Atlas of the Roman Empire.* Digital Atlas of the Roman Empire. https://imperium.ahlfeldt.se/
Foruli	30B.C.E-640 C.E	Town	13.2806	42.3546	Åhlfeldt, J. (2015). *Digital Atlas of the Roman Empire.* Digital Atlas of the Roman Empire. https://imperium.ahlfeldt.se/
Interocrium	30B.C.E-640 C.E	Town	13.0809	42.41601	Åhlfeldt, J. (2015). *Digital Atlas of the Roman Empire.* Digital Atlas of the Roman Empire. https://imperium.ahlfeldt.se/
Aquae Cutiliae	30B.C.E-640 C.E	Town	13.0147	42.3855	Åhlfeldt, J. (2015). *Digital Atlas of the Roman Empire.* Digital Atlas of the Roman Empire. https://imperium.ahlfeldt.se/
Cliternia	30B.C.E-640C.E	Town	13.0234	42.3292	Åhlfeldt, J. (2015). *Digital Atlas of the Roman Empire.* Digital Atlas of the Roman Empire. https://imperium.ahlfeldt.se/
Villa di Tito	100 C.E-700 C.E	Villa	13.0141	42.3851	Åhlfeldt, J. (2015). *Digital Atlas of the Roman Empire.* Digital Atlas of the Roman Empire. https://imperium.ahlfeldt.se/
Villa di Orazio	30 B.C.E-300 C.E	Villa	12.9012	42.0673	Åhlfeldt, J. (2015). *Digital Atlas of the Roman Empire.* Digital Atlas of the Roman Empire. https://imperium.ahlfeldt.se/
Grotti di Torri	30 B.C.E-640 C.E	Villa	12.6721	42.2020	Talbert, R. J. A., & Bagnall, R. S. (2000). *Barrington Atlas of the Greek and Roman world*. Princeton University Press
Monte Calvo, Scandriglia	30 B.C.E-300 C.E	Villa	12.8204	42.1941	Marzano, A. (2007). *Roman villas in central Italy: a social and economic history*. Brill.
Villa di Lucilla	30 B.C.E-300 C.E	Villa	12.7086	42.2656	Marzano, A. (2007). *Roman villas in central Italy: a social and economic history*. Brill.
Poggio Catino	330 B.C.E-300 C.E	Villa	12.6923	42.2952	Åhlfeldt, J. (2015). *Digital Atlas of the Roman Empire.* Digital Atlas of the Roman Empire. https://imperium.ahlfeldt.se/
Villa Vacone	330 B.C.E-300 C.E	Villa	12.6465	42.3809	Åhlfeldt, J. (2015). *Digital Atlas of the Roman Empire.* Digital Atlas of the Roman Empire. https://imperium.ahlfeldt.se/
Ponte Capo d'Aqua	300B.C.E-300C.E	Villa	12.8694	42.4672	Åhlfeldt, J. (2015). *Digital Atlas of the Roman Empire.* Digital Atlas of the Roman Empire. https://imperium.ahlfeldt.se/
Villa di Assio	300B.C.E-300C.E	Villa	12.8114	42.4924	Åhlfeldt, J. (2015). *Digital Atlas of the Roman Empire.* Digital Atlas of the Roman Empire. https://imperium.ahlfeldt.se/
Villa Baciletti	---	Villa	12.6116	42.1522	Marzano, A. (2007). *Roman villas in central Italy: a social and economic history*. Brill.
Villa Volusii	---	Villa	12.6007	42.1332	Talbert, R. J. A., & Bagnall, R. S. (2000). *Barrington Atlas of the Greek and Roman world*. Princeton University Press
Villa Monte Elci	---	Villa	12.7843	42.1747	Marzano, A. (2007). *Roman villas in central Italy: a social and economic history*. Brill.
Villa S. Lucia	---	Villa	12.7767	42.0545	Marzano, A. (2007). *Roman villas in central Italy: a social and economic history*. Brill.
Villa S. Maria Assunta	---	Villa	12.6195	42.2753	Marzano, A. (2007). *Roman villas in central Italy: a social and economic history*. Brill.
Villa Colli Rotti	---	Villa	12.6230	42.2763	Marzano, A. (2007). *Roman villas in central Italy: a social and economic history*. Brill.
Villa S. Adamo	---	Villa	12.6529	42.2872	Marzano, A. (2007). *Roman villas in central Italy: a social and economic history*. Brill.
Villa Terme Silla	---	Villa	12.6864	42.2969	Talbert, R. J. A., & Bagnall, R. S. (2000). *Barrington Atlas of the Greek and Roman world*. Princeton University Press

Villa Paranzano	100-200 C. E	Villa	12.6616	42.3223	Marzano, A. (2007). *Roman villas in central Italy: a social and economic history*. Brill.
Villa S. Vito	---	Villa	12.6535	42.3238	Marzano, A. (2007). *Roman villas in central Italy: a social and economic history*. Brill.
Villa Colle Tulliano	---	Villa	12.6370	42.3234	Marzano, A. (2007). *Roman villas in central Italy: a social and economic history*. Brill.
Villa Foglia	---	Villa	12.4789	42.3288	Marzano, A. (2007). *Roman villas in central Italy: a social and economic history*. Brill.
Santa Maria Legarano	---	Villa	12.6749	42.3549	Marzano, A. (2007). *Roman villas in central Italy: a social and economic history*. Brill.
Villa Cottanello	---	Villa	12.6776	42.4003	Marzano, A. (2007). *Roman villas in central Italy: a social and economic history*. Brill.
Villa Grignano	---	Villa	12.5923	42.3702	Marzano, A. (2007). *Roman villas in central Italy: a social and economic history*. Brill.

Appendix C: All datasets used in Analysis.

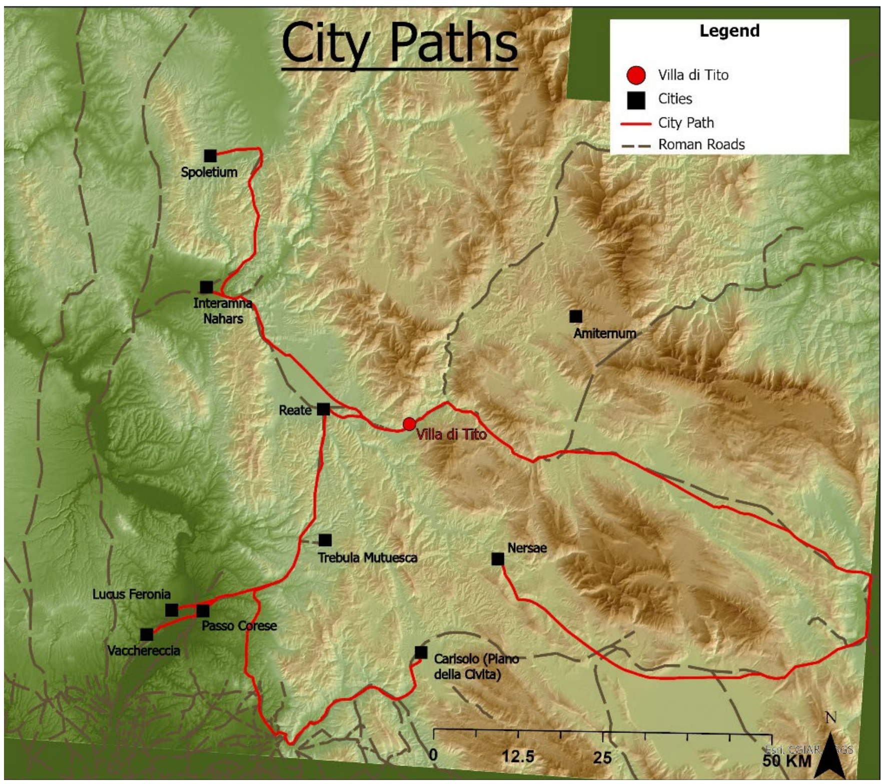
This appendix shows all the datasets used for this analysis. This includes raster datasets obtained from databases and layers created within ArcGIS Pro.

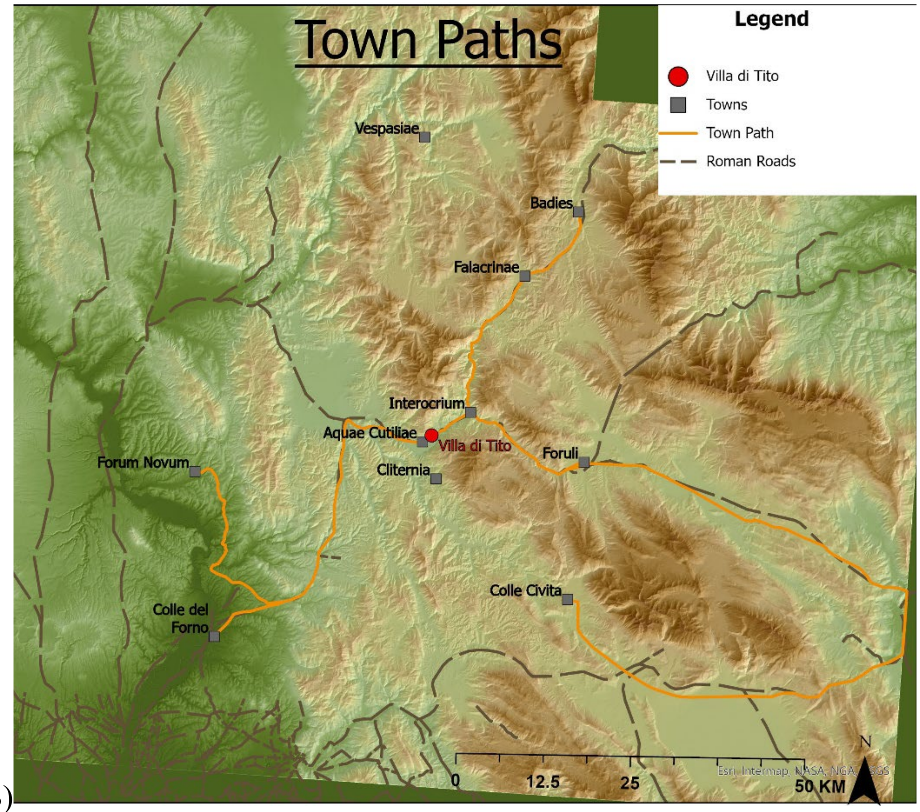
Layer name	Datatype	Measurement	Source	Geoprocessing tool used to create dataset
VillaTitoPoint	Point	---	---	Multipoint feature class
Villas_Roman	Point	---	Refer to Appendix B	Multipoint feature class
Towns_Roman	Point	---	Refer to Appendix B	Multipoint feature class
City_Roman	Point	---	Refer to Appendix B	Multipoint feature class
Station_Roman	Point	---	Refer to Appendix B	Multipoint feature class
CnItaly_DEM_10m	Raster	10m	TinItaly	---
Gen_DisAcu	Raster	10m	---	Distance Accumulation
Gen_DiscuAcu_BD	Raster	10m	---	Distance Accumulation
Slp_CnItaly	Raster	10m	---	Slope (Spatial Analyst)
Asp_CnItaly	Raster	10m	---	Aspect (Spatial Analyst)
SlopeBarrier	Raster	10m	---	Set Null
CostRaster	Raster	10m	---	Raster Calculator
RomanRoads_Remake	Polyline	---	Mapping Past Societies (formally DARMC)	Edited in modify feature class
GeologicalMap	Raster	10m	Geoportale Regione Lazio	---
StudyArea	Polygon	---	Boatwright, 2012; Talbert and Bagnall, 2000).	Create polygon feature
Elementildrici_Lazio	Polyline	---	Geoportale Regione Lazio	
VelinoRiver	Polyline	---	---	Create polyline feature and traced from Elementildrici_Lazio
TiberRiver	Polyline	---	---	Create polyline feature and traced from Elementildrici_Lazio
SpecchiAcqua_Lazio	Polygon	---	Geoportale Regione Lazio	
OptPath_City	Polyline	---	---	Optimal Path as a Line
OptPath_Town	Polyline	---	---	Optimal Path as a Line
OptPath_Station	Polyline	---	---	Optimal Path as a Line
AllPaths	Polyline	---	---	Create polyline feature
SolRad_Fall	Raster	10m	---	Area Solar Radiation
SolRad_Winter	Raster	10m	---	Area Solar Radiation
SolRad_Summer	Raster	10m	---	Area Solar Radiation
SolRad_Spring	Raster	10m	---	Area Solar Radiation

Appendix D: Optimal Path Maps

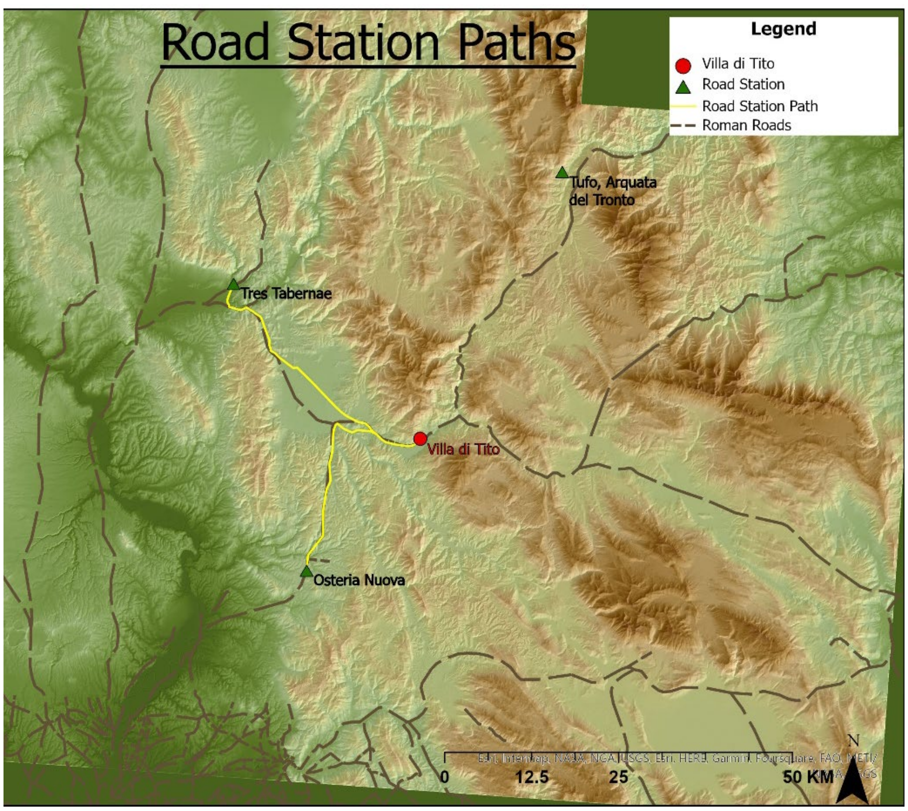
These collected images reflect what the optimal paths as a line look like for each category. This divides the paths into cities, towns and road stations which were layered together in Figure 4.8. They are listed as the following: A) displays the city paths created towards the cities B) displays the town paths created to the Town C) displays paths towards road stations.

A)




Town Paths
Legend
Villa di Tito
Towns
Town Path
Roman Roads
Vespasiae
Badies
Falacrinae
Interocrium
Aquae Cutiliae
Villa di Tito
Forum Novum
Foruli
Cliternia
Colle Civita
Colle del Forno
0
12.5
25
50 KM
N

B)


Road Station Paths
Legend
Villa di Tito
Road Station
Road Station Path
Roman Roads
Tufo, Arquata del Tronto
Tres Tabernae
Villa di Tito
Osteria Nuova
0
12.5
25
50 KM
N

C)

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Aspect (Spatial Analyst). Esri. https://pro.arcgis.com/en/pro-app/latest/tool-reference/spatial-analyst/aspect.htm

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