# Down to the Ground: A Case Study in Predictive Modeling in Scythia Minor

**Nathaniel Durant - Keith F. Otterbein Award**

*During the third to seventh centuries C.E., the Roman province of Scythia Minor, located in modern-day southeastern Romania, was repeatedly overrun by Gothic, Hunnic and other barbarian invasions from the north, which, according to Zosimus, Philostorgios and other historians of the late empire, ravaged the countryside and even led to the capture and destruction of several frontier forts and settlements. Thus, the system of frontier forts that had been established along the Black Sea coast and Danube since the second century C.E. was likely repeatedly modified and developed to combat these persistent threats. Although the fortifications are often separated and categorized by size or function, ranging from smaller towers to larger forts and fortified cities, the purposes of all these constructions ultimately lie rooted in control and defense, and the individual fortifications themselves almost always worked in tandem with other installations. Using two missing sites as case studies, my research takes an interdisciplinary and spatial approach aimed at exploring how these sites can be located, and how their placement affects how people living on this Roman frontier reacted under nearly four centuries of external and internal pressures.*

## Introduction

In the late Roman Empire, the province of Scythia Minor, located in modern-day southeast Romania, remained one of the most militarily active regions of the empire as repeated invasions by the Goths, Huns, and Slavs from the fourth to sixth century ensured the constant attention of the emperor to this region and the frequent upkeep of forts, towns and roads.[1] Thus, the system of forts that had been established along the Black Sea coast and Danube since the second century C.E. was repeatedly modified and developed to combat these threats (Fig. 1). Although archaeological remains of all of the forts named in ancient sources have not been convincingly located, modern researchers are fortunate enough to possess several registers that describe distance between sites, both known and unknown. In particular, two sites, called *Vallis Domitiana* and *Ad Salices*, are mentioned in a third century register as being located in the province of Scythia Minor. However, due to the vast area in which the sites could potentially exist, these distances alone cannot provide a location for these two missing sites. There is significant evidence from the ancient sources that, in setting up their frontier defenses and cities, the Romans took careful consideration of the surrounding landscape and opted for the most strategically viable locations.[2] This project takes into account topographical factors by creating a predictive model based on the geographic arrangement of known forts in order to effectively determine which locations in the landscape were considered to be most suitable for the placement of forts. In addition, lines of sight between Roman fortifications seem to also have played a large role in their construction elsewhere in the empire. Thus, this project also creates a viewshed analysis of several of the forts in the study area to supplement the predictive model and to further constrain and refine the overall possible locations of the two missing sites.[3] Finally, ground-truthing was conducted at a number of locations in southeast Romania in order to determine the validity of the model and to see if any previously unknown sites could be noted based on its predication.

## Study Area and Approach

The fortified installations in Scythia Minor, largely located along the Danube and the coast of the Black Sea, were responsible for the military defense and control of the Roman province. Due to this crucial need for security, the location and placement of the forts must have been a top priority for the Romans in order to ensure the maximum amount of control over the surrounding landscape. Although the fortifications are often separated and categorized by size or function by archaeologists, from smaller towers to larger forts and fortified cities, the purposes of all these constructions


Fig. 1: Fortified sites in Scythia Minor from the 4th-7th century C.E.

ultimately lie rooted in control and defense and the individual fortifications themselves almost always worked in tandem with other installations.[4]

Unfortunately, although a significant number of forts have been located in Scythia Minor, other constructions, only mentioned by name in ancient historical sources, still remain unaccounted for in the archaeological landscape. While often the only evidence of the existence of these locations comes through as a passing mention in an ancient source, occasionally more pertinent details are preserved in the ancient texts. One of the most useful of these texts is the *Antonine Itinerary,* a third century C.E. register that preserved distances in Roman miles between named sites. While many of the named locations in Scythia Minor have already been discovered and their distances confirmed, two sites, called *Vallis Domitiana* and *Ad Salices*, have eluded researchers (Fig. 2). Even though it is possible, based on the distances obtained from the ancient register, to obtain a rough area in which the sites should be located, ultimately the region is too vast to make any clear predications (Fig. 3).

However, it is possible to gain a significant amount of information from the placement of the surviving fortifications in Scythia Minor, which may aid in creating a more precise location for the two missing forts. Although the placement and construction of a Roman fort must have been a complex process which took into account a multitude of circumstances, several of these factors can be predicted and observed based on its location in the landscape. As a fort was ultimately responsible for the control of the surrounding area, its elevation would have played a crucial role. Naturally, a fort on higher ground relative to the surrounding area would be able to survey a much greater expanse than one that was hemmed in by mountains. Even though the builders of a fort could construct lofty towers and walls to create an artificially high viewpoint, such structures would still have had a greater strategic value on ground higher than the surrounding area. This model incorporated two methods for determining the relative elevation that will be discussed in the following section.

The other parameter that seems to have played a large role in the placement of forts in the landscape is the proximity to sources

| From | To | Antonine Itinerary (Rom mi.) | Antonine Itinerary (km) | Actual measured distance (km) | Actual measured distance (Rom mi.) |
|---|---|---|---|---|---|
| Arrubium | Noviodunum | 20 | 29.59608 | 30.2 | 20.4081081 |
| Noviodunum | Aegyssus | 24 | 35.515296 | 27.03 | 18.26593252 |
| Aegyssus | Salsovia | 17 | 25.156668 | 21.97 | 14.84656076 |
| Salsovia | Halmyris | 9 | 13.318236 | 13.31 | 8.994434398 |
| Halmyris | Vallis Domitiana | 17 | 25.156668 | ? | ? |
| Vallis Domitiana | Ad Salices | 26 | 38.474904 | ? | ? |
| Ad Salices | Histria | 25 | 36.9951 | ? | ? |
| Histria | Tomis | 36 | 53.272944 | 42.84 | 28.94977984 |
| Tomis | Callatis | 30 | 44.39412 | 40.03 | 27.05087971 |

Fig. 2: Named sites and distances from the third century Antonine Itinerary.


Fig. 3: Five-kilometer buffer for Vallis Domitiana (light green ring in the north) and Ad Salices (dark green ring in the south).

of water. Naturally, the very location of the province of Scythia Minor is governed by two major waterbodies: the Black Sea to the east and the vast Danube River to the north and west. It is clear that the placement of many of the sites is dictated by the rivers and sea as these bodies of water served not only as barriers against external invasions, but also as a rapid means of transport and communication as well as providing a fast means of drainage. There is epigraphic evidence of the existence of a fleet, known as the *Classis Flavia Moesica,* which was based at *Noviodunum* and patrolled the Lower Danube.[5] For fortifications that were not located on the coast or the Danube, placement along tributaries or even smaller rivers would have ensured similar benefits.

In addition to these two factors, it is clear that the Romans placed a great deal of emphasis on lines of sight between frontier fortifications so that information could be quickly and accurately conveyed through signaling. Previous research has already demonstrated that this was most likely practiced in Scythia Minor.[6] Although there are significant gaps in the frontier defenses (consisting of the very forts this project aims to locate), it is possible to determine what areas are visible from the existing sites and which areas would benefit from further surveillance. Thus, the combination of a viewshed model with a predictive model based on the other topographical factors will produce a clearer view of the most likely locations for the two missing forts.

## The Model

The base elevation map for this study comes from NASA's worldwide Shuttle Radar Topographic Mission (SRTM) which generated a worldwide digital elevation

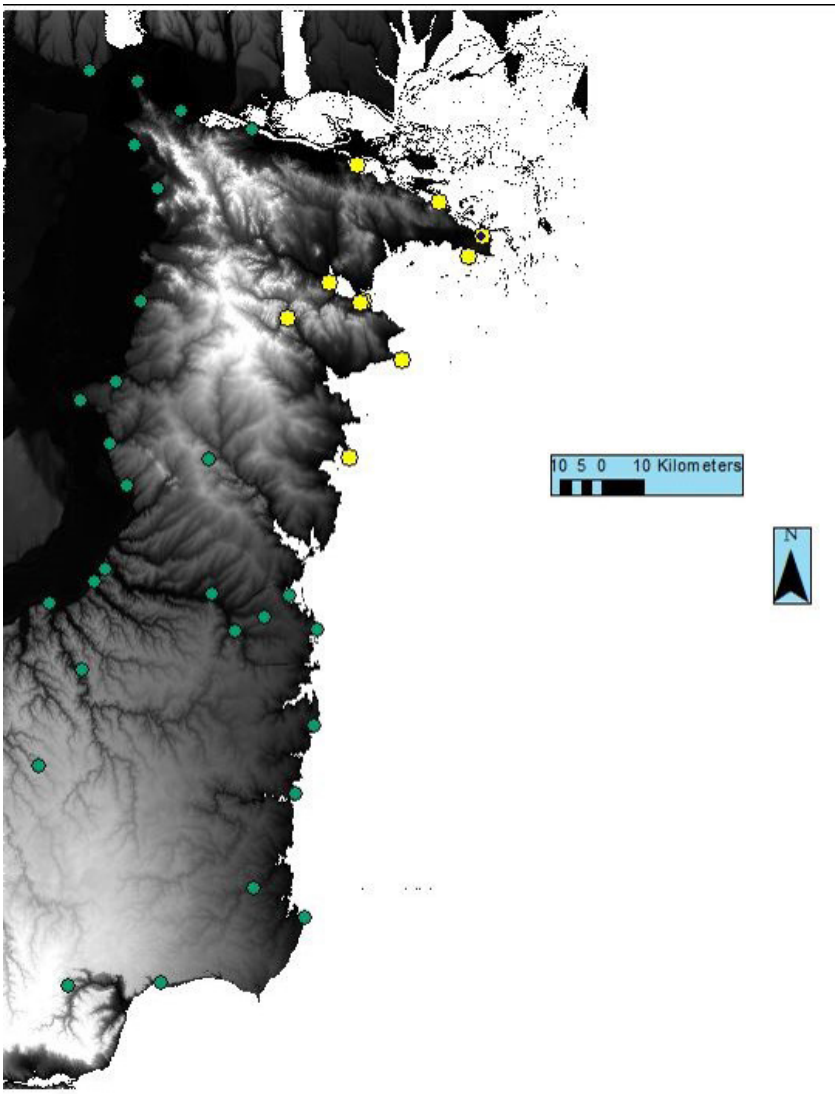


Fig. 4: DEM of Scythia Minor showing locations of chosen sites (yellow dots represent sites likely close to the missing forts).

model (DEM) with a resolution of one arc-second, or approximately 30 m. Although the resolution of this DEM is perhaps not ideal for mapping out detailed ground features, it is largely appropriate for this study as almost none of the fortifications are smaller than 30 $m^2$. The DEM was reprojected into UTM 35N to ensure the highest degree of accuracy for distances and areas. The locations of 60 fortifications in Scythia Minor, dating from the fourth century to the seventh century C.E. were obtained from archaeological gazetteers (i.e. Zahariade 2006; Bajeanaru 2010) as well as through Cronica, the digital database of the National Archaeological Record of Romania (cronica.cimec.ro) (Fig. 4).

One of the most significant problems that this project encountered was determining the degree to which the landscape had changed since Roman times, especially along the Danube and the Black Sea coast. There has been extensive geomorphological research done in the area of the Danube Delta in the past century that has revealed a complex and changing environment (i.e. Romanescu 2011). In addition to the changing course of the Danube, the past layout of the Black Sea coast differed noticeably from its present day arrangement due to fluctuations in sea level.[7] In order to compensate for all of these complex geomorphological changes, the course of the Danube was modelled after its greatest extent and the sea level on the DEM was changed to 2 m higher than present day, a value that seemed to be an efficient compromise with the sea level values calculated at various archaeological sites.[8] The course of the interior rivers of the Scythia Minor province proved much easier to model, although, due to the available data, it was assumed that their courses remained similar in modern times to their Roman counterparts. In order to determine the influence of major rivers and streams versus those with a more seasonal or temporary nature, four different maps were created based on different minimum amounts of flow accumulation as major streams and rivers will be fed by a considerable amount of runoff while smaller creeks and river valleys might only contain water infrequently.

While the base elevation values were simply extracted from the DEM to the fort points, the relative elevation of each fort was calculated using two different methods. One simply used the neighborhood statistics tool in a rectangular pixel grid (3x3 pixels, 5x5, etc.) to determine the average elevation value of the surrounding area and then subtract this value from the center point. The second method employed a tool popularized in landscape analysis and geomorphology commonly known as TPI (Topographic Position Index). Like with neighborhood statistics, TPI compares the elevation of a point to surrounding values in order to classify the type of landscape (peak, valley, etc.) but does so using a slightly different algorithm and tool developed by Jenness and employed in a number of geological and archaeological papers.[9] The TPI values at various larger distances (i.e. 5x5, 10x10) were created. Finally, as slope may have played a role in the placement and occupation of Roman forts, slope was also added as a parameter into the model.

In all, twelve individual parameters were used within the development of the model. A binary logistic regression curve was selected to be the best model to represent this data, as it is highly sensitive to changes at the 50% margin. As there are only two possible outcomes of this project, either the presence or absence of a fort, the binary logistic regression model served as the best approximation of the real-world data. In order to create location of presumed fort absence, this project generated an equal number of random points using ArcGIS' Create Random Points tool, a common process in statistical analysis. Therefore, 120 points (60 forts, 60 random points) were put into a binary logistic model using IBM SPSS statistical software.

Results and Ground Research

The results from this computation were largely successful, demonstrating the validity of the model ($R^2$=.617), and multiple parameters were determined to have statistical significance (Fig. 5). Based on the statistical values, proximity to major rivers and/or the Black Sea coast was definitely a factor in fort occupation and placement in Roman times, along with height around the surrounding landscape. Interestingly, for relative elevation within a 150 m radius (5x5 pixels as each pixel is 30 m), the TPI indicated a negative relationship (i.e. preference for a lower placement in the landscape) while my method suggested the opposite association. This is especially odd as all other pertinent parameters of relative elevation suggested a

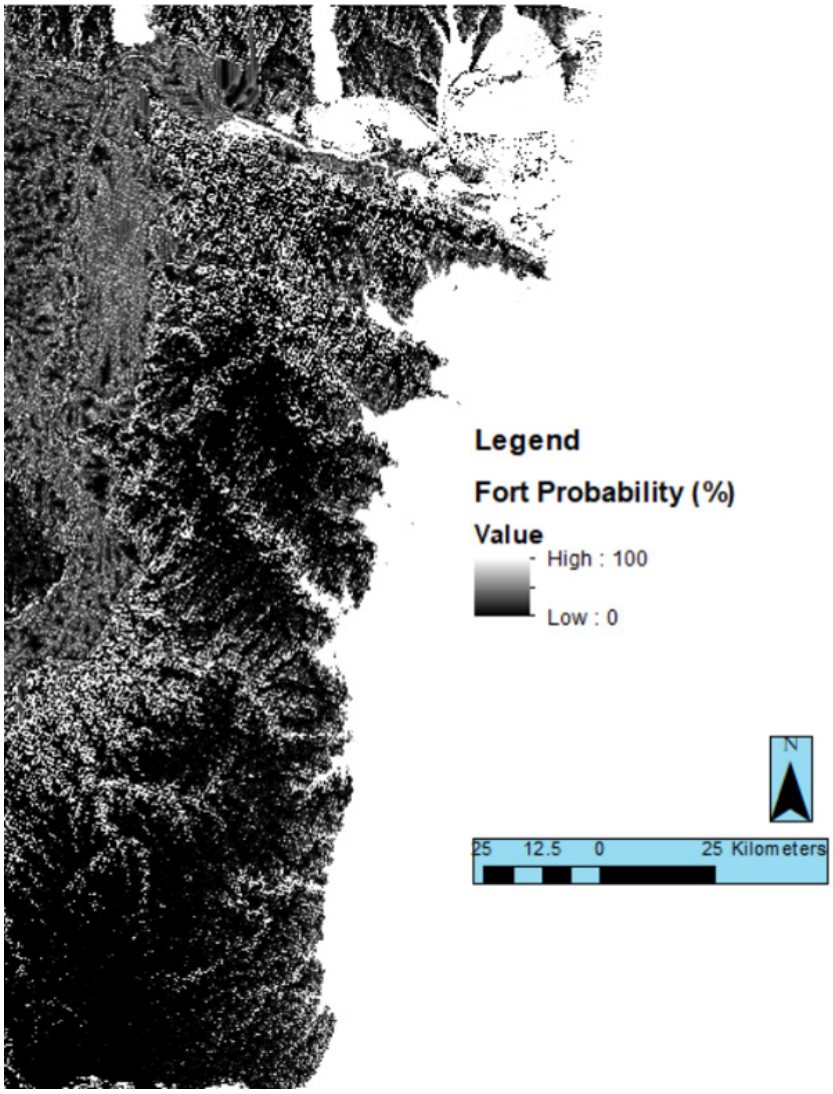


Fig. 5: The final predictive model.

positive relationship and this anomaly will have to be further explored in subsequent research.

A number of high probability sites were chosen for ground research in the summer of 2019 based around the areas of interest for *Vallis Domitiana* (Locations for *Ad Salices* were unfortunately inaccessible (Fig. 6). Field surveys were conducted at a number of these sites and considerable amounts of pottery and ceramic building material (CBM) were processed. The results of these surveys revealed the presence of three previously unknown sites of the Roman period, as well as four other sites that displayed Roman material culture. The absence of any considerable amounts of worked stone and the fact that only one of these sites contained significant levels of CBM suggests that these sites were most likely not forts. However, it is possible that much of the subsurface features had been largely removed by plowing and other modern interventions.

Discussion

While this model did not locate any sites that could be convincingly identified as forts by pedestrian surveys, the fact that Roman material was discovered at multiple locations should be considered a significant victory for the use of predictive modeling in archaeology. The idea that the Romans took careful consideration of the topography when placing their sites is well known from historical sources such as the first century author Vitruvius, but the statistical similarities present between the known sixty forts in the province of Scythia Minor provide further evidence of the importance of the landscape. The rivers and coastal sites within frontier regions, long believed to have aided in the movement of goods and soldiers to and from fortifications, are clearly seen as one of the major reasons in determining a location for a site.[10] The predicted locations for *Vallis Domitiana* are significant as this site likely occupied a region along the southern coast of the Dunavat peninsula allowing surveillance of the major waterways into Lake Razim and ultimately the Black Sea. If either of the Roman sites discovered within the initial study area do represent *Vallis Domitiana*, the location offers considerable visual control over the flat landscape as well as the main access points to Lake Babadag while providing connections between sites on the Danube frontier and those in the interior of the province.

Unfortunately, none of the areas surveyed within the predicted area of *Ad Salices* revealed any considerable amount of material culture, but this may be due to a limited degree of access. While the study area for *Vallis Domitiana* was largely composed of plowed agricultural land, the region for *Ad Salices* contained considerable numbers of low rolling hills currently covered in dense vegetation and largely inaccessible in the modern day. The model suggests that several of the hills that fall within the study area


Fig. 6: Sites with Roman material culture identified from field survey.

represent ideal locations for a military fort, due likely both to their proximity to the coast as well as their considerable elevation over the surrounding region. Therefore, it is the author's opinion that one of these hills represents the most likely location for *Ad Salices* in the province of Scythia Minor as this location would also allow considerable communication between the Roman fort at Enisala and the fortified settlement at Argamum.

There are however a number of improvements that can be made on these existing models to ensure a greater degree of accuracy of measurements and thus foster improved future research. Although a DEM with a higher degree of resolution would result in a more accurate portrayal of the landscape, access to satellite imagery in Romania remains much more constrained than in other countries. Moreover, a higher resolution might not result in any major differences in the model as none of the forts measures less than 20 m on a side and thus corresponds fairly well with the 30x30 m pixels. Indeed, the greatest issue was not due to the resolution of the DEM, but rather with the mapping of the forts themselves, for even though many of the forts were hundreds of meters in area (and thus would have occupied multiple pixels), each known fort was simply represented by a single point. Thus, it would be highly advantageous in future developments of this model to create a polygon for each fort, not only to accurately portray its size, but also to ensure that a correct elevation value was taken for each one.

Another aspect that this initial project neglected to consider was the temporal development of the Roman frontier system as a whole. While all the forts chosen appeared to be occupied in the sixth century C.E., many of the forts had been built as early as the first century C.E. and were subsequently abandoned, destroyed or rebuilt throughout the history of the province. Naturally, the abandonment or destruction of a fort during a given time period would have had significant consequences for the other forts in the network as a whole. Thus, this model could be adapted based on the datable occupation layers at each fort to give an overview of the frontier system at specific periods of time, and to determine if there were any differences in fort placement from one century to the next.

Finally, there are several parameters that these models do not take into account that could be adapted and added in future manifestations. Since the Romans had an extensive road network in the province of Scythia Minor, the location of these roads and their role in connecting the landscape must have had a significant impact on the placement of forts due to the need for effective routes for transporting goods and soldiers.[11] Adding a least cost path aspect to the models to approximate the location of roads would provide much needed insights concerning the way that forts interacted with each other, and also would help determine how effectively the frontier system operated as a whole. While it is fortunate that so many forts have been discovered through excavation, field survey and aerial and satellite photography, it is very likely that there are still hundreds of forts that are still largely unknown, a fact attested by dozens of names from late Roman documents that have yet to be attached to any archaeological remains. Predictive modelling thus can serve as an effective and low-cost method for determining possible locations of Roman forts.

*Editorial note: All figures are available in color at www.chronikajournal.com*

Endnotes:.

1 Zahariade 2006, 25-6.
2 Johnson 1983, 40.
3 Rodgers 2013, 11-2.
4 Bajenaru 2010, 10.
5 Zahariade 2006, 91.
6 Rodgers 2013, 10.
7 Romanescu 2011, 240.
8 Romanescu 2011, 240.
9 Jenness 2005; Tagil and Jenness 2008; De Reu et. al. 2011.
10 Breeze 2012, 92.
11 Zahariade 2006, 30.

Works Cited:

Bajenaru, C. 2010. *Minor Fortifications in the Balkan-Danubian Area from Diocletian to Justinian.* National Museum of Romanian History: The Center for Roman Military Studies 8, Cluj-Napoca.

Breeze, D. 2012. *The Frontiers of Imperial Rome*. Barnsley: Pen and Sword Books.

De Reu, J., J. Bourgeois, J. De Smedt, A. Zwertvaegher, M. Antrop, M. Bats, P. De Maeyer, P. Finke, M. Van Meirvenne, J. Verniers, and P. Crombé. 2011. "Measuring the relative topographic position of archaeological sites in the landscape, a case study on the Bronze Age barrows in northwest Belgium." *JAS* 38:3435-3446.

Jenness, J. 2005. "Topographic Position Index" (tpi_ jen.avx) Extension for ArcView 3.x. *Jenness Enterprises*. http://www.jennessent.com.

Johnson, S. 1983. *Late Roman Fortifications.* London*:* Batsford.

Rodgers, G. 2013. "Fortifying the Landscape: An Experimental Approach to Late Roman Fortification Strategies and Martial Landscapes." MSc. diss., University of Sheffield.

Romanescu, G. 2011. "Geoarchaeology of the ancient and medieval Danube Delta: Modeling environmental and historical changes. A review." *Quaternary International* 293:231-244.

Tagil, S., and J. Jenness. 2008. "GIS-based automated landform classification and topographic, landcover and geologic attributes of landforms around the Yazoren Polje, Turkey." *Journal of Applied Sciences* 8(6):910-921.

Zahariade, M. 2006. *Scythia Minor: A History of a Later Roman Province (284-681).* Amsterdam: Hakkert.