

MODELLING SETTLEMENT LOCATION IN THE TROAD USING GEOGRAPHIC  
INFORMATION SYSTEMS.

By

Dominick Kevin Del Ponte

Submitted to the Faculty of

The Archaeological Studies Program  
Department of Sociology and Archaeology

In partial fulfillment of the requirements for the degree of  
Bachelor of Science

University of Wisconsin-La Crosse

2013

Copyright © 2013 by Dominick Kevin Del Ponte  
All Rights reserved

# MODELLING SETTLEMENT LOCATION IN THE TROAD USING GEOGRAPHIC INFORMATION SYSTEMS.

Dominick Del Ponte, B.S,

University of Wisconsin-La Crosse, 2013

The Hellenic period began around 2,700 years ago in the Troad. This was followed after a short period of turmoil by the Hellenistic around 2,200 years ago. These periods are characterized by the introduction of Greek culture and colonization. Many of these colonial sites have been discovered in recent archaeological survey. Despite this, the settlement data is still incomplete. It is the goal of this study to assist in the locating of Hellenic and Hellenistic sites through the creation of a predictive model using GIS. This model has made evident the need to continue exploration of the Troad.

## **ACKNOWLEDGEMENTS**

Thank you to: My instructor Dr. Joseph A. Tiffany. My faculty readers Dr. Mark Chavalas and Dr. Gargi Chaudhuri. My student readers Marianna Clair and Megan Lorence. Dr. Peter Jablonka, and Dr. William Aylward for providing data sets.

## INTRODUCTION

When investigating an area for archaeological significance a series of steps must be taken, in, attempt to not only locate sites but also to determine how they relate to each other. Often these steps include historical research, ethnographic research, and general survey practices. While these methods are effective in locating sites, they can be exorbitantly costly and incredibly time consuming due to the amount of ground that needs examining. The prohibitive cost of survey work may also lead to a certain amount of archaeological bias in a region. Survey bias can effectively distort the glimpse into the past that archaeologists are attempting to garner. The primary cause of this bias is the lack of time and funds to run full survey work based on regional sample designs. Thus, the choice must often be made to survey either around a known site or to survey in a location that has no guarantee of uncovering anything, leading to lost time and money.

An example of this bias would be the Troad. The Troad is roughly outlined by the modern day Turkish province of Çanakkale as highlighted in Figure A1. The extent of the Troad has never been precisely established, however, it is loosely defined by the Greek geographer Strabo as the area seen in Figure A2. This area was occupied by the Hellenic and Hellenistic people from roughly 700 B.C. to 146 B.C. when the Romans captured the region. The potential survey bias in the region comes from the area around the City of Troy. Due to Troy's high visibility, the immediate vicinity has been the focus of more extensive survey than the surrounding areas of the Troad. The more intensive survey of the immediate area around Troy has led to a higher density of sites directly surrounding Troy than the rest of the Troad.

This study examines archaeological bias in the Troad as well as predicts where unknown settlements may be. This was done using Geographic Information System (GIS) to take into account several variables that may have played into settlement location decisions by the Hellenic and Hellenistic peoples. Using GIS, I developed a predictive model to illustrate areas of high probability thereby narrowing the areas that are in need of survey.

## **BACKGROUND**

The Hellenic and Hellenistic periods were characterized by Greek coastal cities that until 427 B.C. were under the rule of the Mitylene's from the isle of Lesbos (Cook 1973:360). The exact date that Greek occupation began is under debate; some authors claim to have evidence of occupation pre-700 B.C. (Cook 1973:361). Despite this, settlement occupation of Asia Minor began around 7400 B.C. shown through the site of Çatalhöyük (Fairbarn 2010:202). While Çatalhöyük is within Asia Minor, it is not in the Troad. However, it lends credence to the idea that the Troad had continuous occupation for thousands of years before the Greek arrival. The continual occupation of the Troad created a blending of people and social structure in the early Hellenistic period as Greek city life entered the Troad. The social structure changes required the local people to adjust to a slightly different way of living from their own as the concentration of people increased. Due to settling from Greece most of the cities developed along the coast. The primary coastal settling created a network of cities that had high density near the coast but were more spread-out inland (Cook 1973:363). This spreading is believed to have allowed Hellenic people the full control of nearly all of the land in the area. Despite this control the cities,

especially inland, were isolated allowing them to easily fall into the hands of tyrants and dynasties until the end of the fourth century when the Hellenistic period began (Cook 1973:363).

### **Hellenistic Period**

Until 427 B.C., the cities within the Troad fell under control of the Mitylene followed by the control of Athens. Athen's rule was rebuked by the local dynasty of Zenis and Mania of Dardanos. The loss of control from Athens created a period of instability in the fourth century, as there was no longer a league of cities to offer protection from the myriad of warlords. This period of turmoil ended in 334-332 B.C. when Alexander liberated the Greek cities. At this time, nearly 20 cities sprang up in celebration of their freedom. Despite under Greek control once again, there was still only roughly 100,000 people in the rather larger area of the Troad (Cook 1973:64). This rather low population was a problem for them, as they could not defend themselves against the warlords that were still in the region, and they had little to no political influence.

The multitude of small cities were not considered viable independent units. Therefore, Antigonus "the one eyed" began combining many of these smaller cities into larger more viable political units. Antigonus was the Satrap of Greater Phrygia that included the Troad. He was placed as Satrap in 333 B.C. by Alexander as he conquered Asia Minor (Anson 1988:471). The condensing of the population undertaken by Antigonus may have been to not only increase the viability of these cities in the political arena but also allowed them to be easily defended as Phrygia contained Alexander's vital supply line back to Greece as he pressed further east. This supply line was under near constant threat from the Persians navy until its surrender during the siege of Tyre (Anson 1988:473).

## **METHODOLOGY**

This analysis is based upon the use of GIS processes that allows for the creation of maps compiled from various sources of data to visualize and interpret the issues of settlement pattern discrepancies and survey bias within the Troad.

### **Geographic Information Systems (GIS)**

GIS is a powerful computational method to examine the spatial relationship among data through the creation of maps where real world objects are virtually reconstructed through points, polygons, and lines. These objects may range from population to vegetation to elevation and much more. In addition to analyzing single entities, GIS are capable of analyzing multiple forms of data including spatial, temporal, and statistical components. When these components are used together, they allow for the creation and visual representation of data to illustrate what is happening in a region. There iarea myriad of GIS programs available, this project uses the highly regarded ArcMap 10.1 produced by ESRI, was utilized for this study.

The following summary of GIS is derived from Longley et al. 2011. GIS processing systems use data in primarily two forms: raster and vector. Raster data is used to show continuous features such as slope and vegetation, as well as being the format of all images. Raster data is composed of a series of cells formatted in a grid structure. This grid formation allows for a binary yes or no system to be used as every cell may only have one trait. While raster data uses cells and grids to denote land features, vector data is composed of a series of nodes and arcs that are connected to form the geographic features. Vector data's use of lines and

nodes allows it to represent accurately the location of discrete features such as streams, roads, pipes, and other system networks. Both raster and vector data are stored within the GIS as a single operable feature. For the purposes of this study, a mix of vector and raster data was utilized depending on the feature that is being addressed.

After the data has been assembled and depicted in either raster or vector format a series of processes may be run depending on the data format. Buffer distance is the establishment of concentric rings emanating from a central shape such as riverbed or archaeological site location. The buffer distance allows these areas to be classified by probability dependent on their distance from the given object.

A group of similarly classified layers within GIS may be overlain on each other to show where all of the buffer probabilities are the highest. The data buffering can then allow for the statistical analysis of the probability zones to show the chance of a site being located within the zones shown upon the overlay map.

### Georeferencing

In order to understand some of the processes used to compile the data for this project, an understanding of the concept of georeferencing is important. Georeferencing is defined as “the assigning of a unique location to atoms of information” (Longley et al. 2011:124). This is the taking of pieces of information that are not spatially located and giving them the same fixed locational references. In order to ensure quality and ease of use, georeferencing has three principle rules; that all points are unique, that the meaning of the reference is shared to all, and that the points used to georeference are temporally stable. These rules are important to avoid distortion of the map as well as confusion about the location being referenced due to duplicate potential reference points such as city names as well as the landscape changing over time.

## **Recent GIS in Archaeology**

Predictive modeling in archaeology via GIS has been done with great success recently as can be seen through the modeling work done by Melanie Riley in Mills County Iowa where she created a seven variable predictive model for earth lodge sites that yielded 71% accuracy (Riley 2010). While both Mills County Iowa and the Troad are relatively easy areas to survey predictive, modeling is very useful in areas of harsh terrain. GIS predictive modeling has been used to predict the locations of site in the jungles of Belize. The modeling done in Belize was a six variable model that predicted with an accuracy of 75%. Models such as this have allowed for the discovery of previously unknown sites because of the narrowing of the survey areas (Ford et al. 2000).

## **Projection and Datum**

As part of georeferencing raster data and to maintain accuracy throughout the creation of the model, a standard for projection must to be established. The projection and datum used for this study is the WGS 1984 projection and datum. This projection was chosen because it is the most universally accepted format for cartography today. A standardized projection and datum is necessary in order to maintain uniformity within the mapping and to allow for easier sharing of data between cartographers as a known and standardized projection allows for easier access and understanding of the map.

## **Data Collection and Parameters**

### Settlement Locations

The known settlement locations in the Troad were provided by Dr. Peter Jablonka (Aslan et al. 2012). The points in Figure A3 represent all Hellenic and Hellenistic sites in the Troad ranging from settlements to forts to trading outposts. The settlement locations are represented by vector data points.

### Water Bodies

The establishment of water bodies is a critical step in analyzing the settlement locations of the region. This was done by georeferencing multiple maps to extract as much information as possible while allowing for the crosschecking of the older maps to help insure the accuracy. After georeferencing, a feature layer representing the water bodies was digitized by tracing the visible features to develop the map as depicted in Figure A4. The larger permanent bodies of water such as lakes were already digitized by the Natural Resource Department of Turkey. One water aspect not represented is the presence of small springs or wells such as the springs under the wall of Troy as described by Homer (Strabo1923:200). This is due to the data not being present for small temporally short springs or streams two thousand years ago.

### Slope

The slope data seen in Figure A5 has been extracted from the Shuttle Radar Topography Mission (SRTM) conducted in 2000. The SRTM data has a 3-meter resolution.

## Soils

The soils of the region were surveyed in 1956 by the Turkish Ministry of Agriculture. The map in Figure A6 is the 1956 map that was used as the base map for the soil layer. The survey broke the region into seven distinct soil categories. These seven categories in order of fertility are hydromorphic saline soil (shown in blue), developed under the once paleo-sea of the Trojan plateau. Alluvial and youthful soils (shown in purple) are relatively new and fertile soils created through decomposition of organics or the movement of material through alluvial (windblown) processes. Noncalcic brown rendzina soil material (shown in red) is lacking in calcium and soil depth creating a rather acidic and shallow soil that is not as hospitable to all plant life as the previously mentioned types (Lal 2002:1127). Brown forest and podzolic soil material (shown in horizontal green bands), is of lesser fertility due to the inherently low fertility of forest soils (Lal 2002:587). Terra Rosa soil material (shown in red diagonal bars) is a shallow clay rich material. Brown forest soil (shown in green) is also lacking in fertility due to the low water holding capacity of forest soil (Lal 2002:587). Moderately sloping rendzina soil material (shown in grey) has higher erosional rate due to its shallow depth and slope making it less suitable for agriculture (Lal 2002:1127).

## Coastline

The nature of the Hellenic and Hellenistic people being sea faring people as well as relying upon trade from Greece for many things made them more apt to settle along the coast. Therefore, the coast provides a critical component within this analysis. The coastline was created through the georeferencing of satellite imagery.

## **Data Processing**

The data processing is fashioned in such a way to provide five categories to each parameter stated above. The categories are based on distance to water, soil fertility, and degree of slope. The categories are highly probable, somewhat probable, moderately probable, somewhat improbable, and improbable. This categorization is done so that the maps may be overlaid on each other to show the high probability zones when every variable is taken into account.

## Settlement Locations

The settlement locations received a buffer of 1km increments extending outward to 4km after which all distance is given the same weight. The 1km buffer distance seen in Figure A7 represents the catchment distance or the area from which a settlement will draw the majority of its resources. Due to the catchment, distance required for site stability the area furthest away from neighboring settlements is considered to be of the highest probability. Despite the arbitrary catchment buffer only six sites fall within the somewhat improbable and improbable categories placing 82% of all sites within moderately probable to highly probable.

## Water Bodies

The water bodies were given a buffer in 1km increments extending out to 4km after which everything is grouped as one. These distances were used because 1km is roughly a thirty-minute walk, allowing for relatively easy access to fresh water Figure A8 shows this buffer distance of streams in relation to known sites showing that 90% of all sites fall within 2km of a river or within the higher groups of probability. Figure A8 does not include the lakes although the layer is present in the final overlay seen later. Lakes have been given the same buffer as streams. This layer does not take into account the location of springs and temporally short streams.

### Slopes

The 0-90° slopes have been broken into five natural interval segments. Natural interval is a computation that allows for the greatest degree of variability between the classes while grouping the items of highest similarity together. Since the natural interval computation of the data, is done via computer, user bias is eliminated from this stage. The intervals give lesser slopes a higher degree of probability while assigning steeper slopes a lower probability. The reclassification gave favorability areas of lesser slope that would be more evident of fertile plains than the steeper areas of more rocky topography as seen in Figure A9. Approximately 75% of sites are located within the highly probable and somewhat probable ranges.

### Soils

The seven soil types were condensed into five categories based on their fertility. Figure A10 demonstrates this as brown forest and podzolic soil material, brown forest soil in mountainous terrain and moderately sloping rendzina soil material were grouped into a single unfavorable category. After reclassifying 54% of sites fall within the highly probable or somewhat probable categories.

### Forests

The original seven soil layers have been reclassified into five forest layers. This was done based on if the soil in the region showed evidence of a forest environment at some point in the past. This method has been done because the modern forested areas are likely to not have been the forested areas in the Hellenic and Hellenistic periods. This process created the map as seen in Figure A11. The forest layer contains 64% of all sites within highly probable or somewhat probable.

## Coastline

As stated earlier the coast is an important feature in the landscape of the Hellenic and Hellenistic people of the Troad. With that in mind, the coastline as seen in Figure A12 has been given a 3km interval buffer up to 10 kilometers after which everything is grouped. This has been done due to the connection with Europe and the known sites showing a trend within 3km of the coast. Despite this connection, only 57% of settlements are within 3km of the coast.

## Overlay and Summary

The final stage of the modeling process is to overlay all of the previously shown layers on a single map. This is done through a weighted sum of all of the layers. What is done in a weighted overlay is the combination of the previously mentioned layers into a single entity. All of the created layers have the same scaling from highest probability to lowest probability in order to maintain a uniform scale for the overlay process. This process allows the six layers to be placed one on top of the other to highlight the areas of high probability they all have in common. While this process is easy to visualize it involves many complex calculations to be run by the GIS in order to maintain accuracy within the map as the maps are overlaid. In addition to placing the maps on top of each other, a weighted sum will give more weight to layers as specified increasing how they affect the outcome. The weights given to the six layers were based upon the probabilities described earlier. These percentages were placed into the weighted sum giving water (lakes and streams) a 0.90 weight while soils had a 0.54 weight, coastline was given 0.54 weight, slope was given a 0.75 weight, known settlement were given a 0.82 weight, and forests were given a 0.64 weight. This differential weighting gives the map more accuracy as geographic features that are of higher probability will a greater impact on the result. In order to help conceptualize the parameters they have been summarized in Table 1.

Table1. Summarization of geographic parameters used.

<b>Class</b>	<b>Highest Probability</b>	<b>High Probability</b>	<b>Neutral</b>	<b>Low Probability</b>	<b>Lowest Probability</b>
<b>Distance to sites</b>	>4 km	3-4 km	2-3 km	1-2 km	0-1 km
<b>Soil fertility</b>	Hydromorphic Saline	Alluvial and Youthful	Non-Calcic Brown	Rosa Terra	Other
<b>Distance to water</b>	< 1 km	1-2 km	2-3 km	3-4 km	>4 km
<b>Distance to coast</b>	<3 km	3-6 km	6-9 km	9-12 km	>12 km
<b>Percent rise of slope</b>	Natural intervals determined by computer based upon the percent rise. Steeper slopes given lower values, flatter plains given higher values.				

### Buffering Bias

In order to examine the archaeological bias within the Troad directly related to the area surrounding Troy that is currently distorting the settlement distribution seen earlier an arbitrary 20km buffer ring has been placed around Troy. The ring is cropped to the coastline to allow for more visual clarity of the subject matter. This buffer shows that 54% of all known sites are within 20km of Troy. While this may be explained through importance of the City of Troy in the Troad, it is unlikely as seen in Figure A13.

## ANALYSIS AND RESULTS

### Testing the Model

The model is created through a map overlay. In order to test the model the environmental parameters were run without the known settlements catchment buffers as seen in Figure 1. The model predicts within 75% accuracy for known settlements falling within the high or somewhat probable classifications. However, there is a slight geographic anomaly to the southeast of Troy where the once paleo-sea of the Trojan plateau ended. This anomaly is where the Scamander Valley cuts through a small-elevated region that contains a different soil type than the surrounding area. The area that is different in soil type is also topographically different from the rest of the Scamander valley. The majority of the Scamander Valley is as traditional flat river basin while this area is a steep and rocky environment. The small stretch of the Scamander that has incised through this area has four sites on its banks. While this is an important grouping of sites, if they are excluded as anomalous, the model predicts with 86% accuracy. This is not perfect but allows for a decent understanding of where unknown settlements may be located.

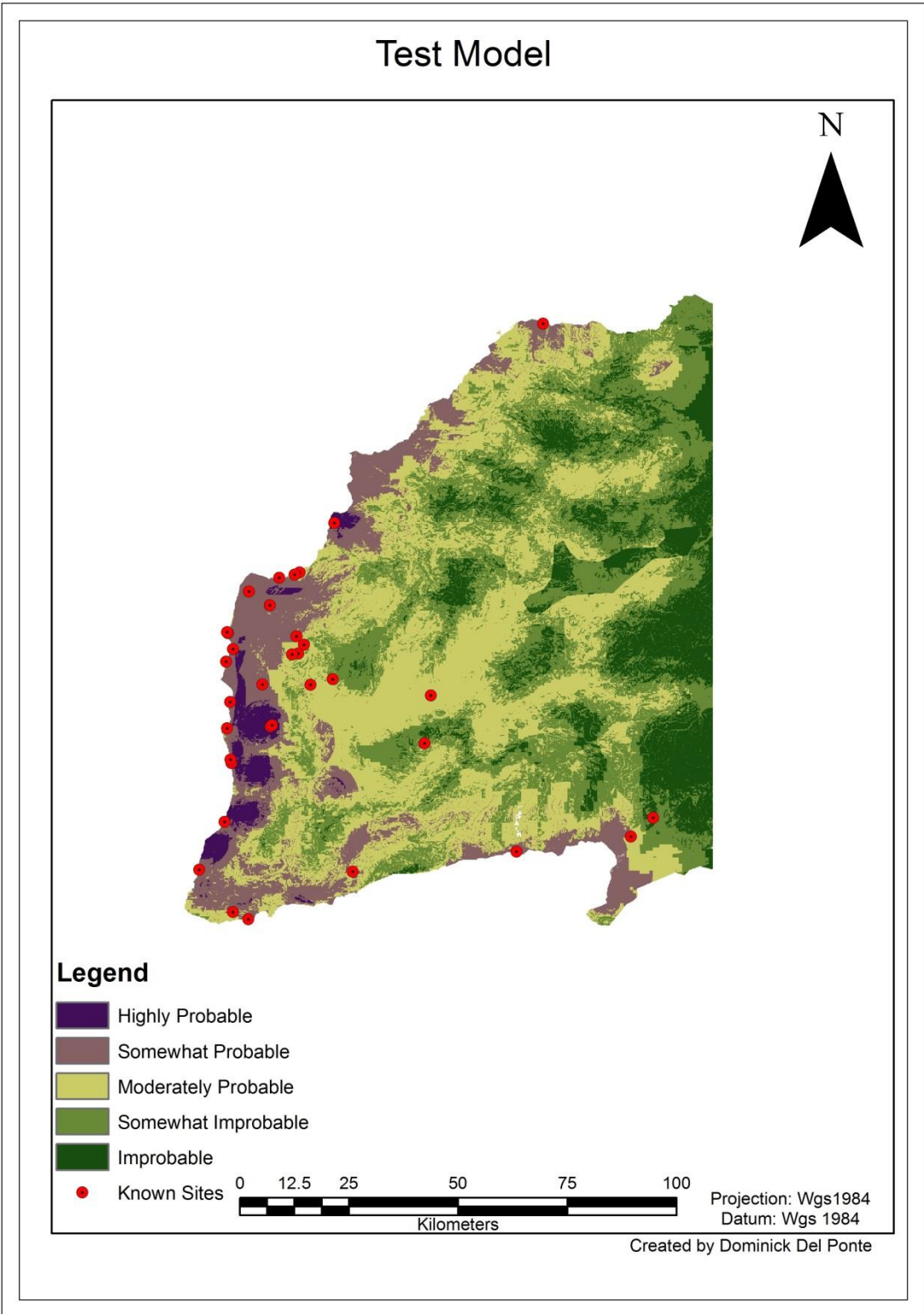


Figure 1. Testing the Model.

## **Analyzing the Model**

The model as seen in Figure 2 shows that while there still are some locations of high probability within the 20km buffer around Troy there is more area of high site probability located in other regions. Figure A14 demonstrates this by inserting the 20km bias buffer as a negative parameter to the map. This is done to highlight the area that should be avoided in survey work, as much of what is there is likely to have been discovered. The density of the high probability is primarily along the coast specifically the Northwestern coast as well as the Southwestern coast as the coastal area between is already extensively covered. In addition, some of the inland areas along Scamander river valley are also of higher probability.

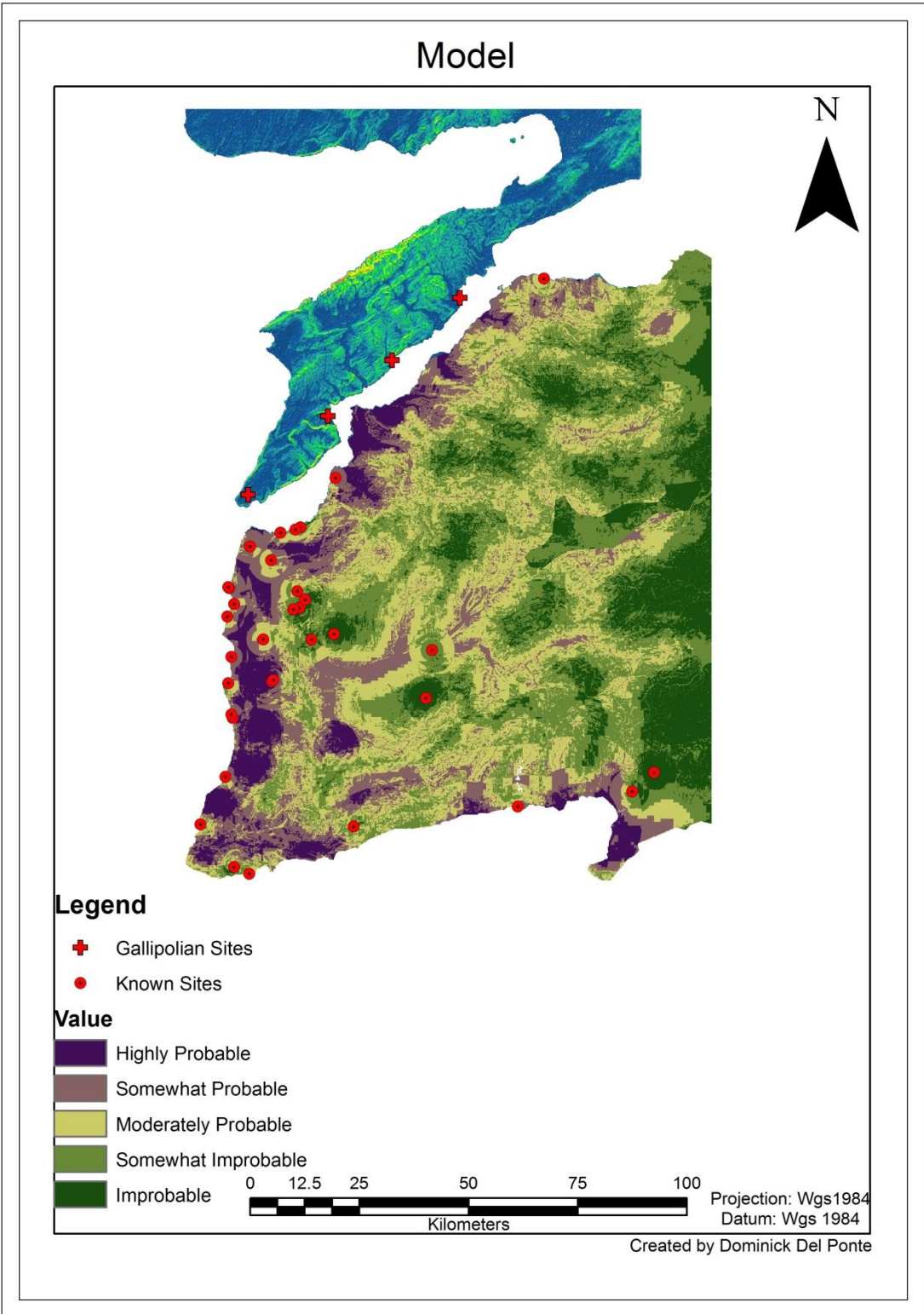


Figure 2 Completed Model.

## **DISCUSSION AND CONCLUSIONS**

The processes involved in the creation of the model provides adequate data for further processes to be run and allows enough flexibility within the model for additional parameters to be added.

The addition of more parameters may alter the accuracy of the model but should not have a great effect on the probability areas. The model has shown three distinct areas of interest, the northwest coast, the southwest coast, and the inland areas. Each area is distinct in the processes that may be causing the presence or lack of sites in relation to the models probability zones.

### The Northwest Coast

The Northwest coast is particularly interesting because of the location of contemporaneous sites on the Gallipoli peninsula located just 1.2-6 km on the other side of the Dardanelles. If these site locations are taken into account, a correlation may be able to be drawn between these known sites and high probability zones on the eastern side of the Dardanelles. While this is speculative perhaps a sister port city model may become apparent with further exploration of the eastern side.

### The Southwest Coast

Unlike the northwest coast, the southwest coast does not have any directly relating settlements that may lead to yet further increased probability. Despite this there are a few areas of distinctly high probability shown in purple that should be examined for potential sites particularly due to their relation to larger flowing water sources in the region and there relatively close proximity to the Greek mainland.

## Inland

The inland area does not show the very high probability that the coastline does. However, for inland survey, it appears that looking in the transitional areas between the fluvial plains of the Scamander and its tributaries and the surrounding colluvial toe slopes may be recommended as the few known inland sites are located within this transitional area.

## Suggestions for Further Research

The addition of more environmental attributes to the model may prove to be useful as it would refine and hone the accuracy. However, ground proofing the model may be the next step in order to demonstrate the validity of the model. This may be done through any of the classical survey technique or through remote sensing techniques. For both statistically representative sampling methods are recommended to increase data applicability statistically and enhance future modeling efforts.

# APPENDIX

## MAPPING



Figure A1. Overview of Modern Turkey, Canakkale Province Circled. (nationsonline 2012)



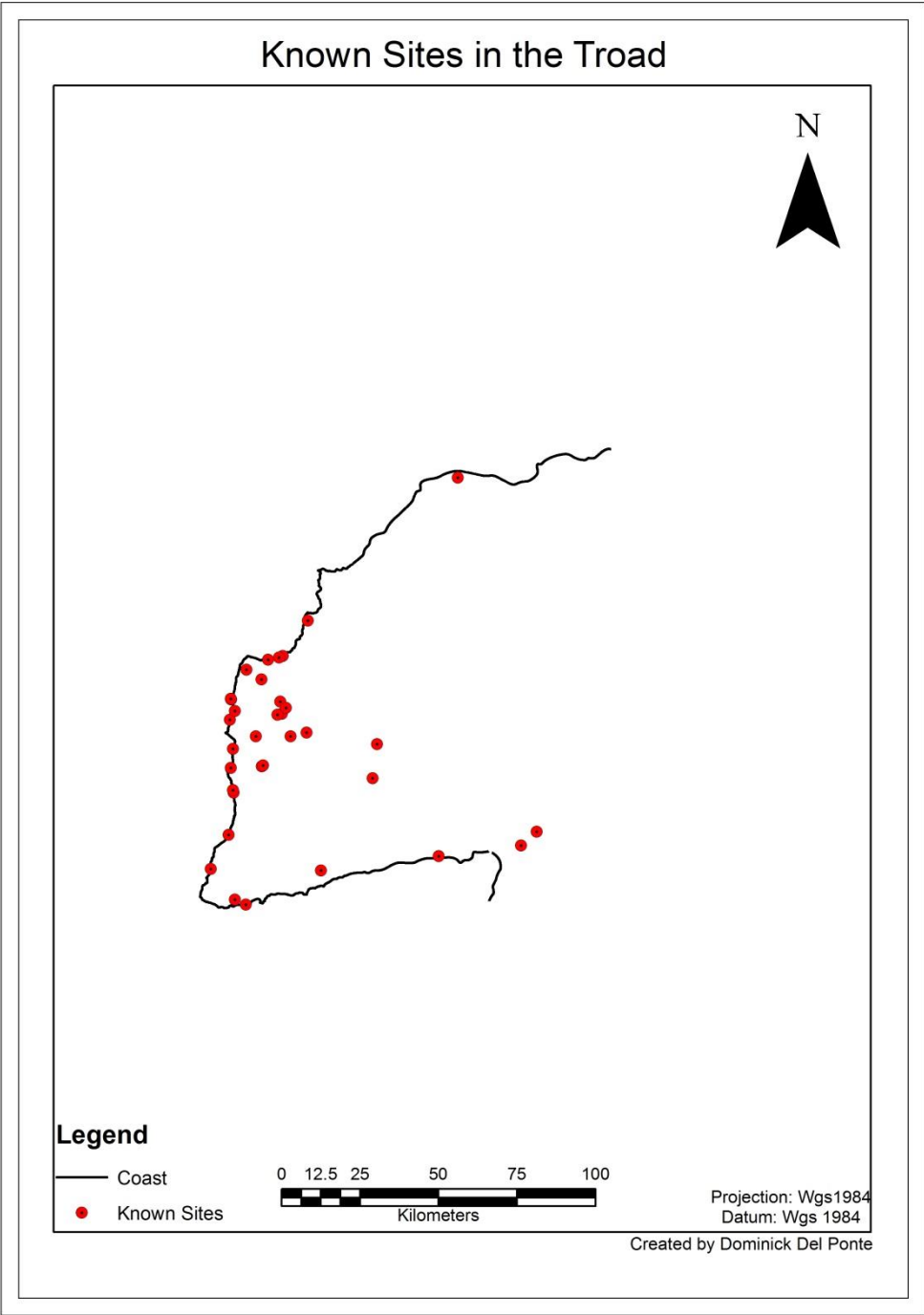


Figure A3. Known Hellenic and Hellenistic Sites in the Troad.

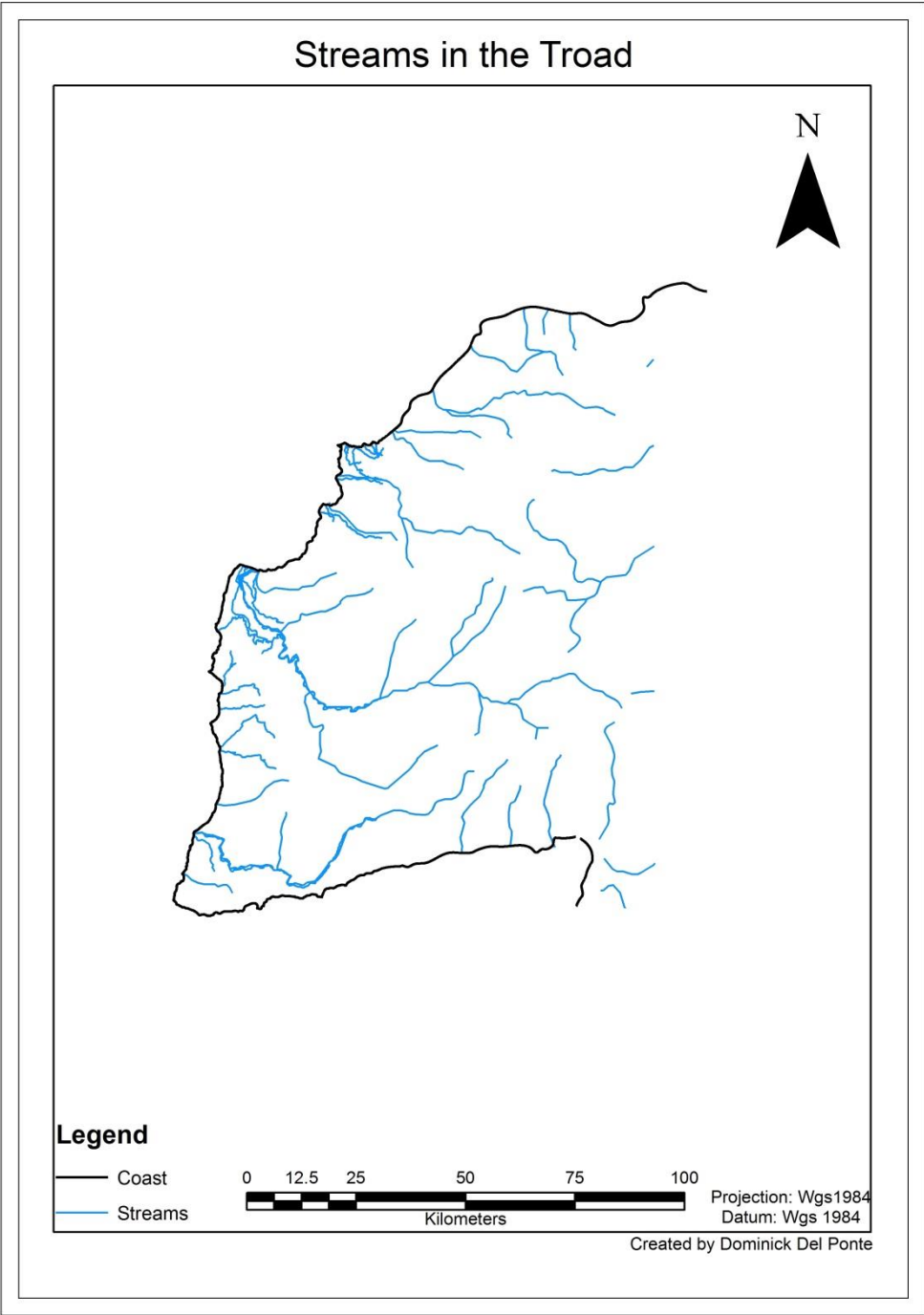


Figure A4. Modern Streams in the Troad.

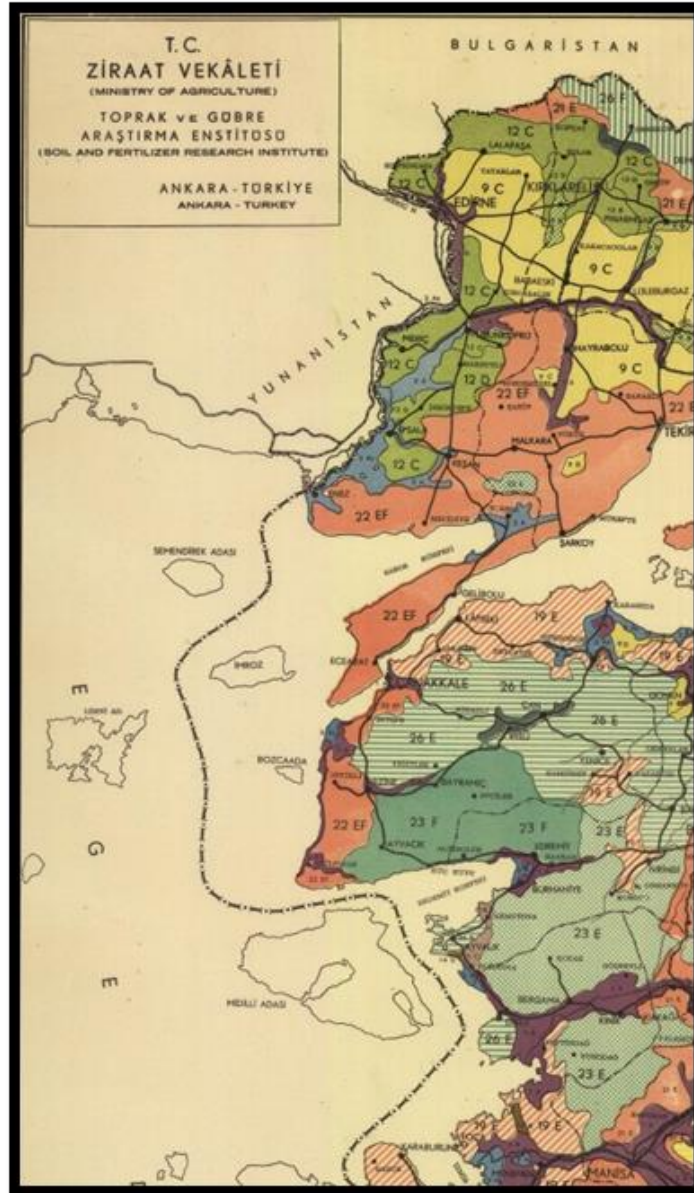


Figure A5. 1956 Soils Map (Ministry of Agriculture 1956).

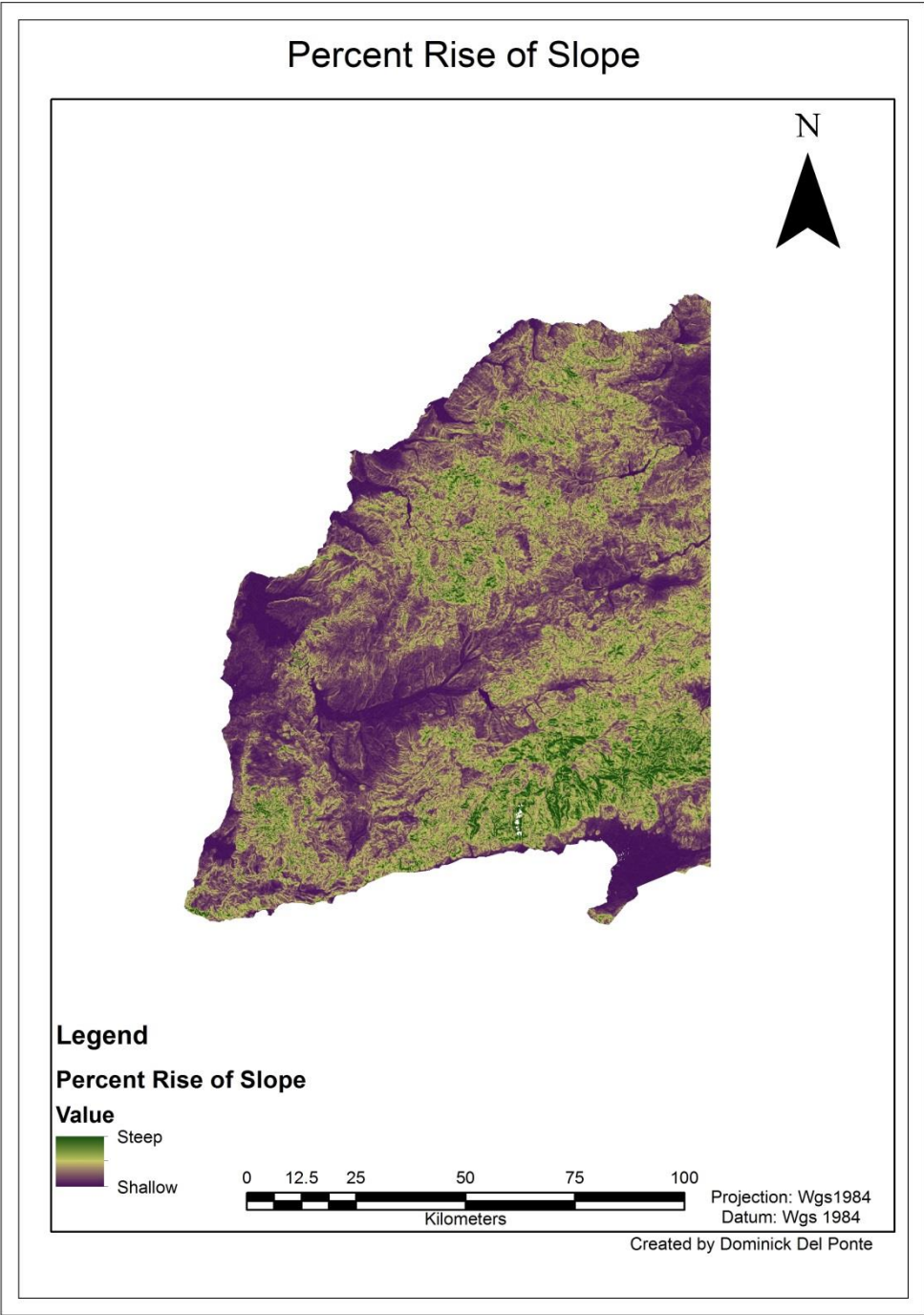


Figure A6. Topography of the Troad.

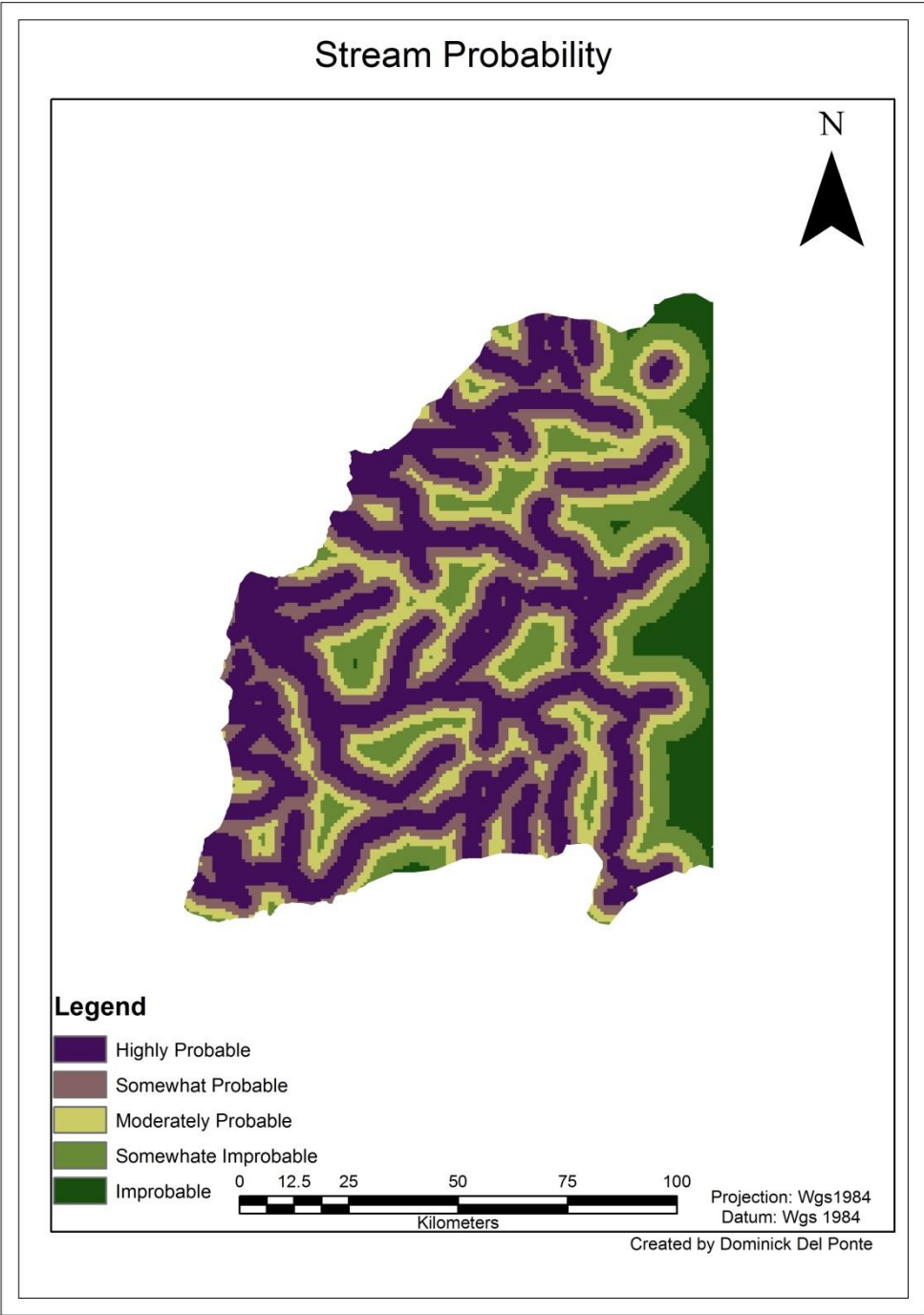


Figure A7. Stream Buffer.

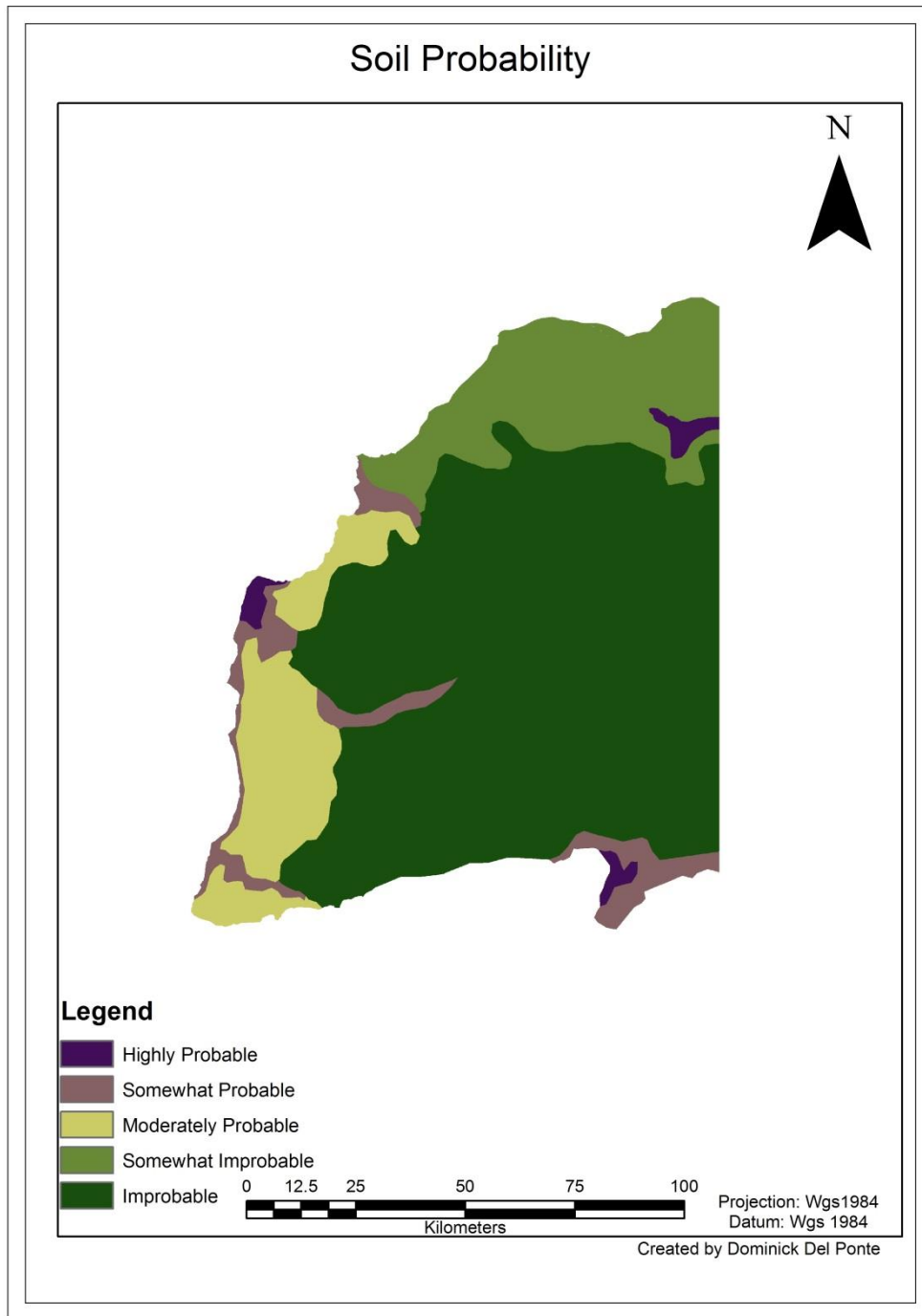


Figure A8. Soil Classification extracted from the 1956 Soil Map, Figure A5.

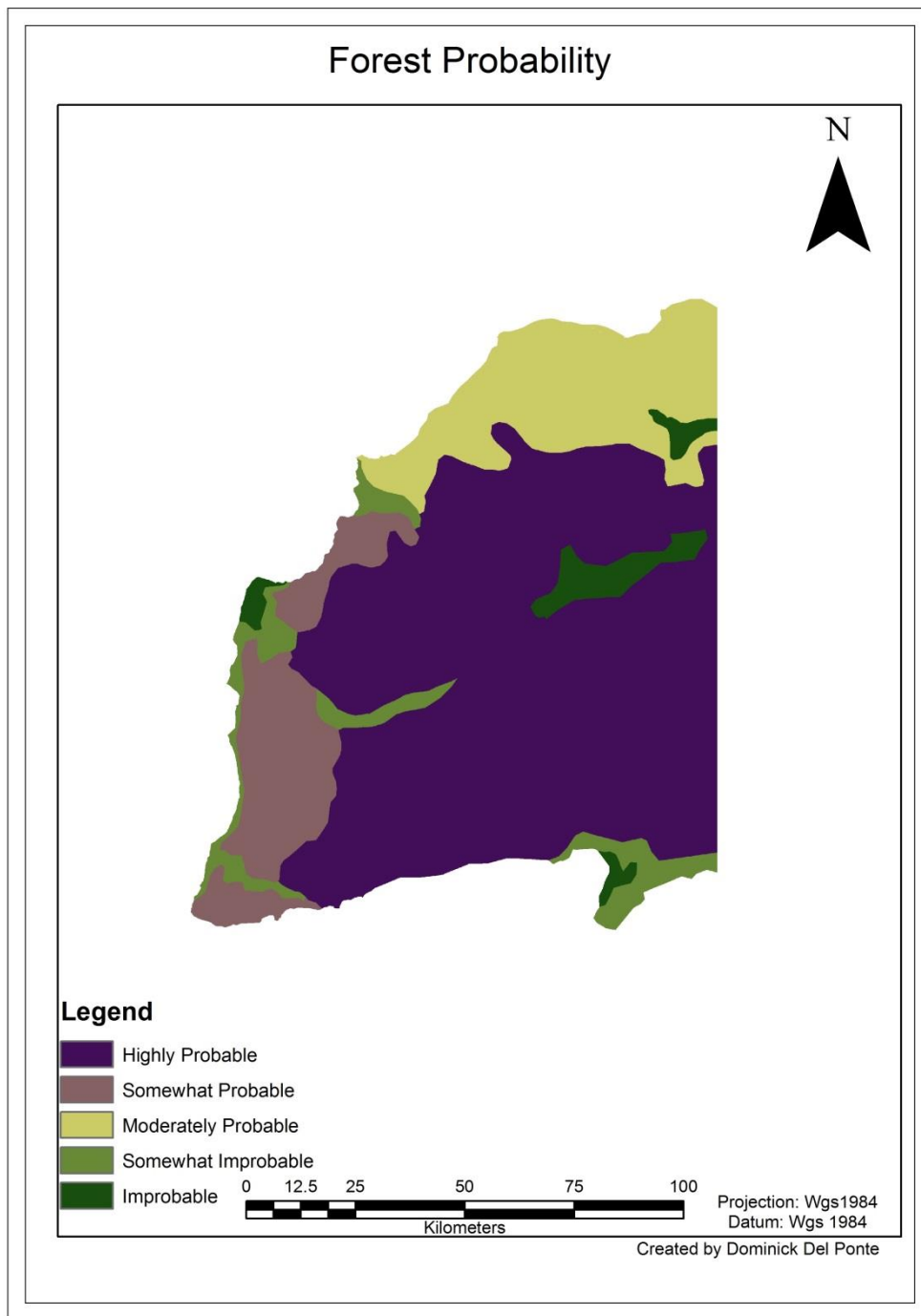


Figure A9. Forest Soils Extracted from 1956 Soil Map, Figure A5.

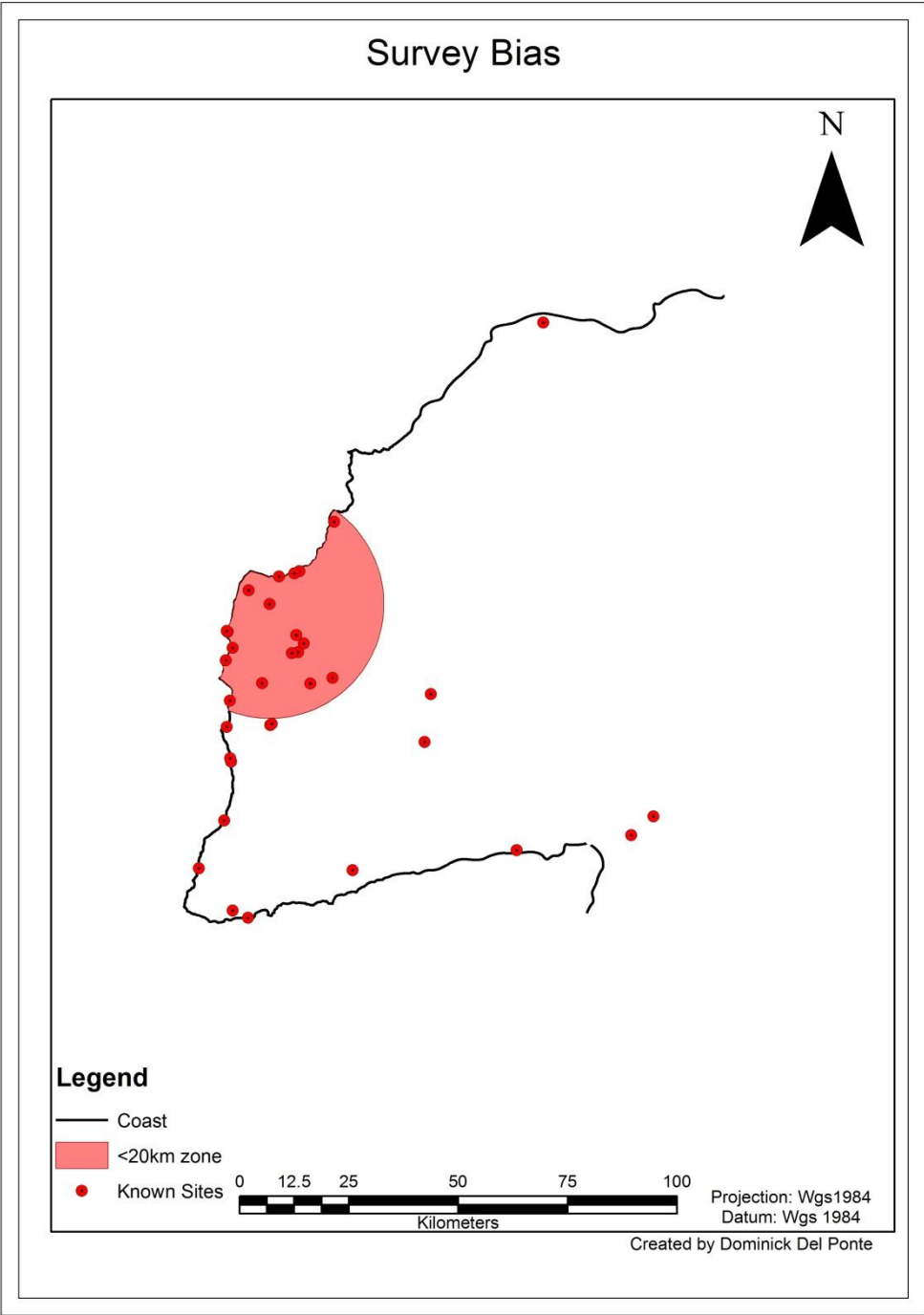


Figure A10. Survey Bias.

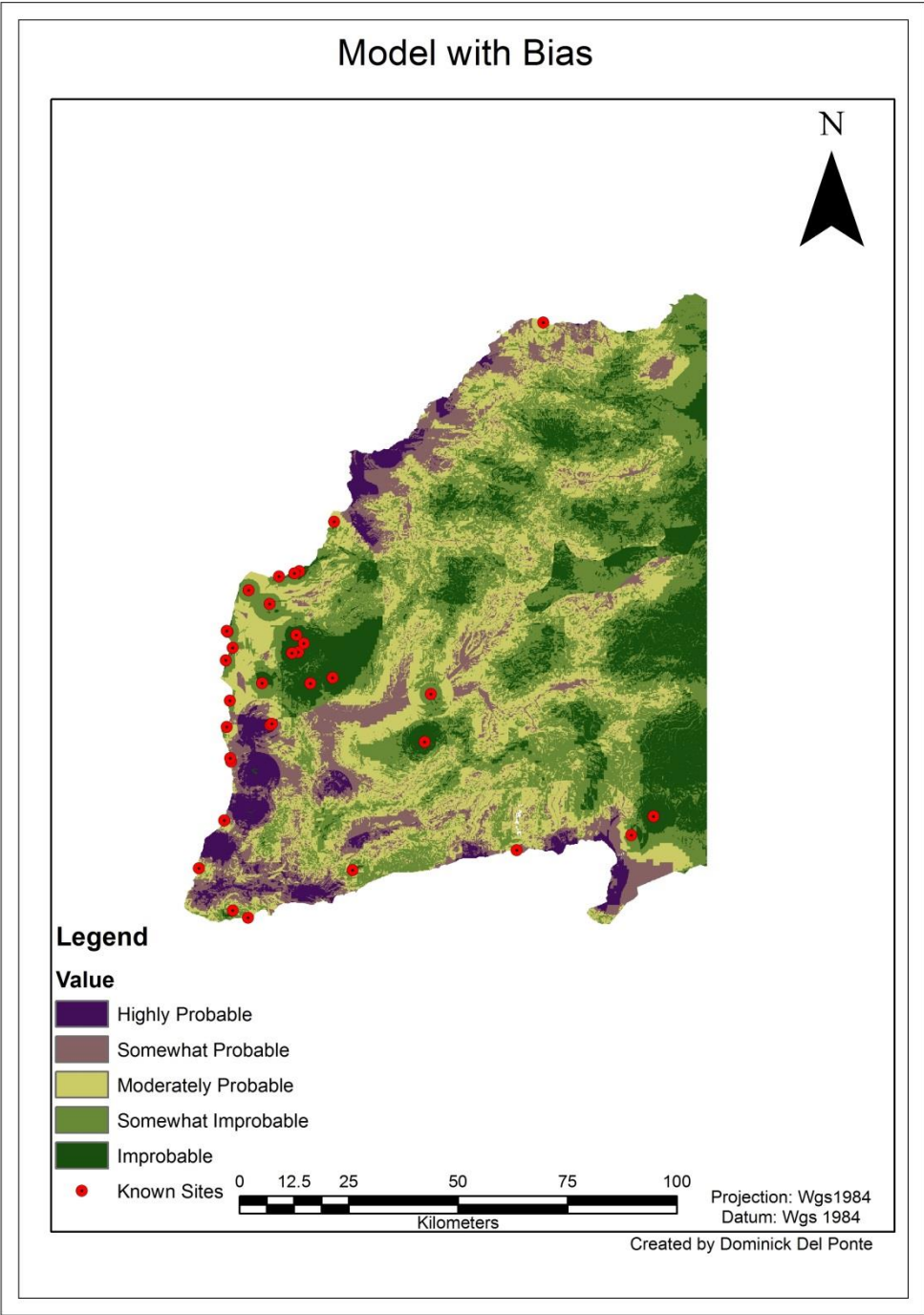


Figure A11. Model With Bias.

## BIBLIOGRAPHY

Aslan, Rüstem, Gebhard Bieg, and Peter Jablonka

- 2012 Unpublished data set for Prehistoric sites in the Troad. On file, Universität Tübingen, Germany.

Cengiz, D.

- 2000 General Directorate of Mineral Research and Exploration. Electronic document <http://www.mta.gov.tr/v2.0/eng/maps.php?id=metallogeny>, accessed February 4, 2013.

Cook, J.M.

- 1973 *The Troad: An Archaeological and Topographical Study*. Oxford University Press, New York.

Fairbairn, Andrew

- 2005 Garden Archaeology. *World Archaeology* 37 2:197-210.

Ford, Annabel, Clark Wernecke, Jose Manuel Chavez, Rudy Larios, and William C. Poe

- 2000 *Assessing the Situation at El Pilar: Chronology, Survey, Conservation and Management Planning for the 21<sup>st</sup> century* BRASS/EL PILAR Field Reports, MesoAmerican Research Center, Institute for Social, Behavioral and Economic Research, UC Santa Barbara.

Gale, N. H., Z. A. Stos-Gale, and G. R. Gilmor

- 1985 Alloy Types and Copper Sources of Anatolian Copper Alloy, *Anatolian Studies* 35:144-173.

Gates, Marie-Henriette

- 1996 Archaeology in Turkey, *American Journal of Archaeology* 100:2:277-335.

Hormann, Christopher

- 2012 View Finder Project. Elevation model  
[http://www.viewfinderpanoramas.org/Coverage%20map%20viewfinderpanoramas\\_org3.htm](http://www.viewfinderpanoramas.org/Coverage%20map%20viewfinderpanoramas_org3.htm), accessed February 13, 2013.

Lal, Rattan (editor)

- 2002 *Encyclopedia of Soil Science*. Marcel Dekker, New York-.

Longley, Edward, Michael Goodchild, David Maguire, and David Rhind

- 2011 *Geographic Information Systems and Science*. John Wiley and Sons, New Jersey.

Nations Online

- 2012 Map the nations project. Electronic document, <http://www.nationsonline.org/>, accessed April 15, 2013.

Ministry of Agriculture

- 1956 Soil and fertilizer research Institute. Electronic document  
[http://eusoils.jrc.ec.europa.eu/EuDASM/TR/TR\\_13001\\_01.jpg](http://eusoils.jrc.ec.europa.eu/EuDASM/TR/TR_13001_01.jpg), accessed January 28, 2013.

Riley, Melody

- 2010 Chapter 6. Weights of Evidence Predictive Model for Earthlodge Sites in the Glenwood Locality, Mills County, Iowa, In, *Cultural Resources of the Loess Hills: A Focus Study to Determine National Significance of Selected Archaeological Cultural Resources Along the Loess Hills National Scenic Byway*. Edited by Melody K. Pope, Joseph A. Tiffany, Angela Collins and Michael J. Perry. Contract Completion Report No. 1700, pages 6-100 Office of the State Archaeologist of Iowa, Iowa City.

Strabo

- 1923 *Strabo on The Troad*. Translated by Walter Leaf. Cambridge University Press, London.

