Auxiliary Forts and Rural Economic Landscapes on the Northern Frontier

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1 Introduction

The impact of the Roman Empire on the physical landscapes of the northern frontier provinces is clear even today.¹ The infrastructure of Roman military occupation, the forts and fortresses, roads, walls, and palisades – known collectively as *limes* – remain powerful reminders that lands from Great Britain to the Black Sea were once ruled by Rome.² In the socio-political context of the late 20th and early 21st century, these ancient, artificial features of the physical landscape and the history they embody are considered so important that they have been combined into a single transnational UNESCO world heritage site.³ The influence on the physical landscape of the northern frontier provinces was profound and durable, but in antiquity, the physical infrastructure was only part of a broader impact that included not only power relations, but demographic and societal shifts. Thousands of soldiers were stationed along the frontiers in bases that became increasingly stable and permanent, and thousands of civilians traveled with them. The Roman army was an institutional network that moved people and goods across great distances. Tax revenues in kind, forced purchases, and conscripts were mobilized through state coercion, officials made contracts with individuals for supplies, and the concentration of money and power attracted entrepreneurs. Thus, the Roman Empire also had a profound impact on the social landscape of the northern frontier provinces.

1 This paper received funding from the European Research Council (ERC) under the European Union's Horizon 2020 research and innovation program (grant agreement no. 742645).

2 The *limes* have long been the subject of a specialized research tradition, well-represented by the *Congress of Roman Frontier Studies*, held triennially since 1949.

3 "Frontiers of the Roman Empire." UNESCO world heritage property ref. 430, listed since 1987 (<https://whc.unesco.org/en/list430/>; last accessed on March 23, 2021). D.J. Breeze and S. Jilek (eds.), *Frontiers of the Roman Empire: The European Dimension of a World Heritage Site* (Edinburgh 2008). See R. Hingley, 'Frontiers and mobilities: the frontiers of the Roman Empire and Europe', *European Journal of Archaeology* 21.1 (2018), 78–95 for a discussion of the contemporary socio-political context.

Finally, by altering both the physical and social landscape, the Roman Empire affected the way that people interacted with their surroundings. Using quantitative analysis of rural settlement locations, this paper investigates the perception of the landscape by the people living in the countryside in the frontier zone. It asks how Roman military demand changed the way rural people valued environmental features, and what role auxiliary forts played in their local cultural-economic landscapes.

Within landscape archaeology, human perception is a key part of what constitutes a landscape. Tim Ingold defined the landscape as “the world as it is known to those who dwell therein, who inhabit its places and journey along the paths connecting them.”⁴ The landscape emerges from the relationship between inhabitants and physical surroundings, depending as much on the situated perspective of the dweller as on the physical form and properties of the environment. It consists of places – meaningful locations where tasks are performed – and the paths that people travel between them. Ingold’s definition of ‘place’ intentionally dissolves the boundary between natural and cultural so that, on the Roman frontier, the Danube and the forts that line it are analytically parallel entities rather than parts of distinct ‘natural’ and ‘built’ environments. Ingold also coined the term ‘taskscape’ to describe the intertwined ensemble of actions that agents carry out in their everyday lives, and considered the landscape to be the embodiment of the taskscape.⁵ For example, the temporal relationship between harvesting and threshing is affected by and affects the distance between the field and the threshing floor.

The theory of affordances, first developed in ecological psychology but increasingly applied in landscape archaeology, also centers on the dialectic between perceiving inhabitants and their surroundings.⁶ In brief, an affordance is an opportunity for or constraint on action that emerges from the relationship between a strategic actor and features of the environment with particular properties. For agriculturalists wishing to separate chaff from grain, a hilltop exposed to the sun and breeze might offer the affordance of effective threshing. The sun would dry the grain, making it easier to break up, and the breeze would carry the chaff away during winnowing. Because of this confluence of strategic actor and environmental feature, and because of the close interlocking of the tasks of threshing and winnowing, the hilltop might become a place

4 T. Ingold, ‘The temporality of the landscape’, *WorldA* 25.2 (1993), 152–174, esp. 156.

5 Ingold 1993, op. cit. (n. 4), 158–161.

6 J. Gibson, *The Ecological Approach to Visual Perception* (Boston 1979); M. Gillings, ‘Landscape phenomenology, GIS and the role of affordances’, *Journal of Archaeological Method and Theory* 19.4 (2012), 601–611; E. Rietveld and J. Kiverstein, ‘A rich landscape of affordances’, *Ecological Psychology* 26.4 (2014), 325–352.

categorized as a threshing floor. Absent the agriculturalists, the breeze and sun still exist, but the affordance of easy threshing does not.

This relational, emergent conception of the landscape invites certain questions: what did different features of the landscape mean to those within it, and how did that change over time? These questions are useful in themselves, but also because the meaning of landscape features and places is contingent on the broader social context of the inhabitants. Studying the changing meaning of landscape features provides an avenue for learning about changes in the broader context. Here, the broader context is the impact of Roman militarization on the rural economy of two areas: the Lower Rhine (Netherlands) and the Lower Danubian plain (Bulgaria). Specifically, I investigate the question of agricultural intensification and the role of auxiliary forts as market places for rural produce.

The presence of thousands of soldiers and associated civilians required increased surplus production. Although the military population could have eaten food imported over long distances, logistical pressures must have encouraged the acquisition of at least some supplies from the frontier zone.⁷ Even in a marginal zone like the Lower Rhine that regularly imported grain, there is also evidence for increased surplus production locally.⁸ This increase in surplus production could have come about through extensification (cultivating more land than before) and/or intensification (investing more labor and capital in cultivation). Intensification in particular implies a certain perspective on the landscape. If the goal is to increase production through the application of one's labor or capital, then the cultivator would seek out places in the landscape that respond particularly well to such an investment. Therefore, evidence that people were sensitive (or more sensitive than before) to local differences in agricultural suitability could be taken as evidence for agricultural intensification.

Beyond increased surplus production, the army is often seen as promoting economic development more generally.⁹ However, serious questions remain about the nature of the army's role in frontier economies and societies.¹⁰ Some

7 M. Reddé, 'The impact of the German frontier on the economic development of the countryside of Roman Gaul', *JRA* 31 (2018), 131–160 argues that the Rhine army acquired supplies from throughout the Gallic provinces at least through the late first century CE and in some cases even longer.

8 M. Groot et al., 'Surplus production for the market? The agrarian economy in the non-villa landscapes of Germania Inferior', *JRA* 22 (2009), 231–252.

9 D. Cherry, 'The frontier zones', in W. Scheidel, I. Morris and R.P. Saller (eds.), *The Cambridge Economic History of the Greco-Roman World* (Cambridge 2007), 720–740.

10 For an overview of recent scholarship on the economic impact of the army in the Lower Rhine frontier, see P. Verhagen, J. Joyce and M.R. Groenhuizen 'Finding the limits of the limes: setting the scene', in P. Verhagen, J. Joyce and R. Groenhuizen (eds.), *Finding the*

see the military as a distinct community, separate from the people who lived beyond the military *canabae* and *vici* that surrounded the camps.¹¹ The long-held idea that soldiers' salaries played a key role in monetizing the northern provinces is also being called into question.¹² Examining the meaning of Roman military bases as 'places', their relationship to other places, and the affordances they might have offered, is one way to make progress on these issues. Here, I ask whether auxiliary forts were seen as market places by rural producers. I focus on auxiliary forts rather than legionary fortresses because, while the latter were larger and wealthier, auxiliary forts were much more common. If they regularly afforded marketing opportunities, the vast majority of people living in the frontier zone would have had access to the soldiers' money and the economic benefits of military occupation would have been widely dispersed. If they did not, any benefits would have been spatially concentrated at legionary fortresses or cities, and probably also socially concentrated in the hands of *negotiatores* who had close relationships to the army.

In this paper, I describe a method for accessing ancient, emic perspectives on landscape using targeted, quantitative spatial modeling.¹³ Using this

Limits of the Limes: Modelling Demography, Economy and Transport on the Edge of the Roman Empire (Cham 2019), 1–19. For the Lower Danube, see M. Duch, *Economic Role of the Roman Army in the Province of Lower Moesia* (Gnieszno 2017). General contributions on frontier economies include C.R. Whittaker, *Frontiers of the Roman Empire: A Social and Economic Study* (Baltimore 1994); C.R. Whittaker, *Rome and its Frontiers: The Dynamics of Empire* (London 2004); H. Elton, *Frontiers of the Roman Empire* (London 1996); P. Erdkamp (ed.), *The Roman Army and the Economy* (Amsterdam 2002); L. de Blois and E. Lo Cascio (eds.), *The Impact of the Roman Army (200 BC–AD 476): Economic, Social, Political, Religious, and Cultural Aspects* (Leiden 2007). For military supply, see J.P. Roth, *The Logistics of the Roman Army at War (264 BC–AD 235)* (Leiden 1999); F. Mitthoff, *Annona militaris: Die Heeresversorgung im spätantiken Ägypten* (Florence 2001).

- 11 B.D. Shaw, 'Soldiers and society: the army in Numidia', *Opus* 2 (1983), 133–160 described the legion as a 'total institution'. More recently, D. Cherry, *Frontier and Society in Roman North Africa* (Oxford 1998) and E.M. Greene, 'Conubium cum uxoribus: wives and children in the Roman military diplomas', *JRA* 28 (2015), 125–159 have identified a pattern of endogamy in military communities. N. Pollard, *Soldiers, Cities, and Civilians in Roman Syria* (Ann Arbor 2000) argued that military and civilian communities in Dura-Europos were segregated, but cf. S. James, *The Roman Military Base at Dura-Europos, Syria: An Archaeological Visualization* (Oxford 2019).
- 12 C. Katsari, 'The monetization of Rome's frontier provinces', in W.V. Harris (ed.), *The Monetary Systems of the Greeks and Romans* (Oxford 2008), 242–266; C. Howgego, 'The monetization of temperate Europe', *JRA* 103 (2013), 16–45.
- 13 I first developed this method in E. Weaverdyck, *Isolation or Integration? A Spatial Analytical Approach to the Local Impact of the Roman Army on the Northern Frontier* (PhD thesis, Berkeley 2016) and developed it further in E. Weaverdyck 'The role of forts in the local market system in the Lower Rhine: toward a method of multiple hypothesis testing

method, I have found evidence for increased sensitivity to local landscape features that suggests agricultural intensification, but the evidence is stronger for the Lower Danube than the Lower Rhine. The results varied even within each study area, showing that the responses to Roman occupation could be highly localized. I found evidence that *some* forts were market places at certain times but rural people did not consistently see them as markets. I also found one surprising result. The rural inhabitants of the Lower Danube in the fifth and sixth century were very sensitive to local landscape features, but their relationship to the landscape was not based on the affordance of agricultural productivity. Rather, it seems to have been based on defense.

2 Methods

My analysis relies heavily on models, strategic simplifications of reality. By ignoring certain details, the model builder highlights those that are relevant to their purpose. In ancient history, models are most commonly used in what Neville Morley has called ‘theoretical history’, which inclines toward the social-scientific rather than humanistic side of the discipline in focusing on general, underlying processes rather than the complex, detail-rich variety of human behavior.¹⁴ Ideally, this difference in focus enriches all of history, providing context for the detailed understanding of human experience and enriching our generalized explanations with examples of processes might play out at an individual scale. On the other hand, the simplification inherent to model building can seem jarringly reductionist, since the analyst appears to be working with ‘facts’ that are empirically unfounded. There are two common responses to criticism in this vein: that the critic has identified an exception that does not vitiate the fit of the model with the majority of cases¹⁵ or the precise discrepancy between model and reality is irrelevant because the logical relationship between the pieces of the model still holds.¹⁶ A less common response is to rework the model to account for the discrepancy.¹⁷ Because they are simplifications, all models are ‘wrong’ to some extent. The questions to ask

through comparative modeling’, in P. Verhagen, J. Joyce and M.R. Groenhuizen (eds.) *Finding the Limits of the Limes: Modelling Demography, Economy and Transport on the Edge of the Roman Empire* (Cham 2019), 165–190.

14 N. Morley, *Theories, Models and Concepts in Ancient History* (London 2004), 7–25.

15 E.g., M.I. Finley, *The Ancient Economy* (Berkeley 1973), 37–38.

16 E.g., K. Hopkins, ‘Rome, taxes, rents, and trade’, in W. Scheidel and S. von Reden (eds.), *The Ancient Economy* (Edinburgh 2002), 190–230, esp. 193.

17 E.g., Hopkins 2002, op. cit. (n. 16), 208–228.

of a model are: is it useful in generating new insights and questions, and are there alternative models that fit the available evidence better?

The latter question highlights the utility of a specific type of model: the quantitative, statistical model. The analysis described below contains a wide variety of types of models, all combined in a digital environment and explored using statistical analysis. There are conceptual models about how people in the countryside might have interacted with people in auxiliary forts and higher-level conceptual models about how space mediates such interactions. There are also very low level models about archaeological data. Observed remains are taken as examples of 'settlements', 'cities', and other types of places. Both types become digital models in a geographic information system (GIS), in which concepts are represented as points, lines, polygons, and raster surfaces with numeric and categorical variables. I also use logistic regression, a statistical modelling technique common in some fields of archaeology, but rarely used in history.¹⁸ Logistic regression in its current form is an automated, iterative technique in which a computer attempts to create a curved line to function as a model of a dataset. Given a set of data points that contain one dependent variable and many independent variables, it writes an equation in which all the independent variables combine to produce the dependent variable. It then iteratively adjusts the weights of the independent variables to bring the curved line closer and closer to the data points. Because the mathematical model (equation) and the data model are quantified in terms of the dependent variable, one can measure precisely how well the model fits the data. Of course, models never fit exactly, but by quantifying that lack of fit the analyst can try to create a new mathematical model using variables that represent a different conceptual model. By translating data models and conceptual models into digital models, and then analyzing the digital models using a mathematical modeling technique, I can determine precisely which conceptual model fits the available evidence better. Keith Hopkins wrote, "Historians are forced to impose plausible and simplifying fictions on a complex and largely irrecoverable past", and "one of the persistent problems in each generation is how to choose between competing fictions."¹⁹ Statistical modeling is a powerful way to choose.

18 K.L. Kvamme, 'Analysing regional environmental relationships', in M. Gillings, P. Hacıgüzeller and G. Lock (eds.), *Archaeological Spatial Analysis: A Methodological Guide* (London 2020), 212–230, esp. 220.

19 K. Hopkins, *Conquerors and Slaves* (Cambridge 1978), 215 for the first part of the quote, p. x for the second.

The measurements in this statistical analysis describe the spatial relationship between rural settlements and various features of the landscape. I take the locations of settlements as strategic choices reflecting the relationship between ancient people and their surroundings.²⁰ In a sedentary, agrarian economy, most people spend most nights in their homes. Settlements anchor the paths people travel in their daily routines and provide us with an ancient perspective for viewing the landscape in terms of affordances by measuring the prevalence and proximity of various landscape features to settlements. By comparing these with similar measurements taken in relation to randomly distributed points representing the entire set of locations available for settlement, we can tell which features influenced settlement location, and therefore draw conclusions about the affordances that were important to the inhabitants.

My conceptual model of the spatial aspect of agricultural intensification comes from cross-cultural ethnographic work synthesized by M. Chisholm, who compared the amount of labor invested in cultivation to the distance between settlement and field.²¹ He found that labor investment declined quickly between one and two kilometers, so I investigate the prevalence of landscape features within 1.5 kilometers of settlements. I assume that cultivators whose taskscape involve frequent trips to their fields will choose to live near the most productive fields. Therefore, if features conducive to agricultural production are more prevalent in this 'settlement territory', I take this as evidence for agricultural intensification. I resist defining such features *a priori* because the impact of the environment on production depends heavily on technology, technique, and crop varieties. Rather, I inductively assess the prevalence of features to determine whether observed settlement preferences are consistent with agricultural intensification. However, conceptual models do inform the factors that I test. In the Lower Rhine, where agriculture is heavily constrained by the meandering river and its alluvial soil, I use a simple landform classification based on a modern understanding of agricultural potential.²² For the Lower Danube, agriculture is less tightly constrained by the landscape. I use the Roman agricultural writers to identify the types of significant factors but do not adopt their opinions on the precise impact of each factor. I examined slope, topographic land form, sun exposure, aspect

20 This is not only true of new settlements. The decision to remain in or reoccupy an older settlement is also related to the local landscape, though in this case the history of occupation might also have played a role.

21 M. Chisholm, *Rural Settlement and Land Use: An Essay in Location* (London 1979).

22 P. Verhagen et al., 'Now you see them, now you don't: Defining and using a flexible chronology of sites for spatial analysis of Roman settlement in the Dutch River Area', *JASc: Reports* 10 (2016), 314–315.

(which relates to wind exposure), soil, and water supply. For the sake of brevity, I focus here on topographic landform, which showed the largest impacts on settlement location.

These conceptual models must be translated into digital models of the ancient environment. For the Lower Rhine, I use a palaeogeographic reconstruction in which the study area is divided into mutually exclusive units consisting of a single landscape category (fig. 12.3). This reconstruction was built by Mark Groenhuijzen as part of the project “Finding the Limits of the Limes”, led by Philip Verhagen, which also used digital spatial analysis to understand economic relations between the Roman army and the local population.²³ Therefore, the scale and categorization are well-suited to the current study, and my results are comparable to those of that project. No such reconstruction was available for the Lower Danube, but because the terrain in this region is less dynamic than in the Lower Rhine, modern topography is an adequate approximation of ancient topography. I derived topographic landforms from a digital elevation model (DEM). For each cell, the algorithm calculates a topographic position index, which is the ratio between its elevation and the average elevation in a neighborhood around the cell. Then the user specifies cutoff values to divide the terrain into ridges (where the elevation is much higher than average), upper slopes (higher), mid-slopes (similar), lower slopes (lower), and valleys (much lower). The addition of slope data separates mid-slopes into plains, gentle slopes, and steep slopes.

My conceptual model of marketing is based on the idea that people who frequently sell their produce at a market place will try to reduce the time they spend transporting goods to market.²⁴ Large-scale landowners who sell their crops through middlemen, might be less sensitive to the precise distance between their estate and the market place. But in this case, the auxiliary fort does not offer the affordance of ‘market place’ to the producer but functions as an abstract, distant market with little immediate importance in their experienced landscape. The purpose of my larger, analytical model is not to test whether forts acted as markets, but as market places. Multiple market places in a region constitute a market system, and while people are likely to travel most often to the closest market, they also have the option of using a more distant market. To represent marketing affordances, I use a ‘Market Potential’ (MP)

23 M.R. Groenhuijzen, *Palaeogeographic Analysis of the Dutch Part of the Roman Limes and Its Hinterland: Computational Approaches to Transport and Settlement in the Lower Rhine Limes Zone in the Netherlands* (PhD thesis, Amsterdam 2018).

24 This idea has support from ancient literary evidence, where peasants selling their produce are described as hastening back to their fields as quickly as possible: Pl. *R.* 2.371c; Apul. *met.* 9.32; Lib. *or.* 50.25–26; Dig. 50.11.2.

FIGURE 12.1 Two versions of the Market Potential variable for the Middle Roman period in the Lower Danube study area. The variable on the left includes cities (including the legionary fortress at Novae), small towns, and cult sites, while the one on the right includes these places as well as auxiliary forts

variable.²⁵ The market potential of a given place is the sum of the purchasing power of each market place divided by its distance from that place. Because we have no good data on actual purchasing power, I assign each type of market a weight according to a scheme designed to highlight the role of auxiliary forts. Cult sites, which might have hosted periodic markets, are given a weight of 1; small towns, with some resident consumers, a weight of 5; and large market centers, including cities and legionary fortresses with many consumers, a weight of 25. When they are included, auxiliary forts with their surrounding settlements are given a weight of 5.²⁶ These weights are a necessary, simplifying assumption that allow me to test hypotheses about the role of auxiliary forts in the marketing system. I create two versions of the MP variable, one that includes the forts and one that excludes them (fig. 12.1). Neither MP variable is a fully accurate representation of the marketing system experienced

25 The MP variable was inspired by the concept of urban potential used by J. De Vries, *European Urbanization: 1500–1800* (Harvard 1984), 154–156.

26 Note that this scheme varies from that used in Weaverdyck 2016; 2019, op. cit. (n. 13), where the goal was to understand the economic impact of the army as a whole.

in antiquity, but by comparing how well the models built using them fit the data, I can decide which variable is a closer approximation. Closer and closer approximations might be achieved by iteratively tweaking the weights of each market place, but my present goal is to understand the role of auxiliary forts, and for that goal, these two versions of the MP variable are enough. Neither will be ‘right’, but one might be more right than the other.

To test these conceptual models as represented in digital models, the archaeological data must also be represented digitally. The spatial scale of my analysis makes points appropriate representations for all archaeological sites. The sites are categorized by chronology and type. The typology used here is meant to highlight economic roles: sanctuaries, small towns, cities, and forts all represent exchange and consumption at varying scales and rural settlements represent agricultural production. I compiled the archaeological dataset for the Lower Danube using the Bulgarian national archaeological database supplemented with published material. It contains 325 sites from the Late Iron Age through the 6th c. CE scattered across 345,975 ha (fig. 12.2). The Lower Rhine archaeological dataset comes from the “Finding the Limits of the Limes” project. It was derived largely from the Dutch national registry of archaeological sites and contains 1,151 sites dating from the Late Iron Age through the mid 5th c. CE across 249,631 ha (fig. 12.3). Verhagen and his team used aoristic dating techniques to refine the chronological precision of their dataset, so there are many more closely dated sites in the Lower Rhine than the Lower Danube.²⁷ Periodization and site numbers for each study area are presented in table 1. The chronological precision and range, and the size of the datasets differ greatly, which influences how we interpret the results of analysis, but since each area is analyzed separately, it does not influence the analysis itself.

TABLE 12.1 Periodization and numbers of rural settlements in the Lower Rhine and Lower Danube study areas. Rural settlement numbers are divided by analytical zone (see below): E = East, W = West, C = Central

	Period	Date range	Rural settlements
Lower Danube	Pre-Roman	Ca. 500 BCE–50 CE	W: 23/E: 75
	Early Roman	50 CE–100 CE	W: 1/E: 1
	Middle Roman	100–275 CE	W: 31/E: 21
	Late Roman	275–475 CE	W: 45/E: 22
	Late Antique	475–600 CE	W: 8/E: 15

27 Verhagen et al. 2016, op. cit. (n. 22).

TABLE 12.1 Periodization and numbers of rural settlements (cont.)

	Period	Date range	Rural settlements
Lower Rhine	Late Iron Age	250–12 BCE	C: 137/E: 123
	Early Roman A	12 BCE–25 CE	C: 131/E: 97
	Early Roman B	25–70 CE	C: 153/E: 116
	Middle Roman A	70–150 CE	C: 222/E: 177
	Middle Roman B	150–270 CE	C: 237/E: 208
	Late Roman A	270–350 CE	C: 153/E: 118
	Late Roman B	350–450 CE	C: 170/E: 133

In addition to the archaeological evidence, the quantitative analyses require comparison datasets. For agricultural intensification, I use univariate analytical techniques that determine if samples are representative of larger populations. I compare the prevalence of landscape features in settlement territories to their prevalence in territories surrounding points that represent all of the places people could have settled. In the Lower Rhine, this was the entire study area.²⁸ For the Lower Danube, I created a comparison dataset that would be biased in a similar way as the archaeological data set. The northern Bulgarian countryside has not been subjected to the same level of archaeological research as the Dutch countryside, and most of the Lower Danube dataset was compiled in a relatively compressed period in the 1980s and early 1990s.²⁹ Therefore, I

28 I used the Zonal Statistics tool in ArcGIS Pro 2.4 to calculate the area of each landform within 1.5 km of each cell in the study area.

29 Excellent archaeological investigation in the Bulgarian countryside is ongoing, but it is more site focused, deepening our knowledge of particular sites more than expanding the number of sites known. Most of the sites in the Bulgarian National Database were recorded during extensive surveys carried out as part of a country-wide effort to document the archaeological heritage of the nation (Weaverdyck 2016, op. cit. [n. 13], 102–105). More recent surveys include the site-focused survey of villas around Nicopolis ad Istrum led by Andrew Poulter (A. Poulter, ‘The field survey: sites and their interpretation’, in A. Poulter [ed.], *The Transition to Late Antiquity on the Lower Danube: Excavations and Survey at Dichin, a Late Roman to Early Byzantine Fort and a Roman Aqueduct* [Oxford 2019], 683–777) and the survey of the countryside between Novae and Sexaginta Prista led by Sven Conrad. To date, the latter has only been published in summary form, S. Conrad and D. Stančev, ‘Archaeological survey on the Roman frontier on the Lower Danube between Novae and Sexaginta Prista. Preliminary report (1997–2000)’, in P. Freeman et al. (eds.), *Limes XVIII: Proceedings of the XVIIIth International Congress of Roman Frontier Studies held in Amman, Jordan (September 2000)* (Oxford 2002), 673–684; S. Conrad, ‘Archaeological survey on the Lower Danube: results and perspectives’, in P.G. Bilde and V.F. Stolba (eds.), *Surveying the Greek Chora: Black Sea Region in a Comparative Perspective*

FIGURE 12.2 Digital model of the archaeological data in the Lower Danube study area, including rural settlements from the Late Iron Age through Late Antiquity and markets from the Mid-Roman and Late Roman periods

compared the distribution of archaeological sites to land cover data from 1990 and to the locations of modern population centers and found that forests and

(Aarhus 2006), 309–331; S. Conrad, 'Die Besiedlung zwischen Iatrus und Novae an der unteren Donau', in R. Ivanov (ed.), *Rimski i Rannovizantijski Selishta v Bulgariya/Roman and Early Byzantine Settlements in Bulgaria* (Sofia 2008), 68–81.

FIGURE 12.3 Digital model of the archaeological data in the Lower Rhine study area including rural settlements from the Late Iron Age through the Late Roman B periods and markets from the Early Roman A through Late Roman B periods

areas farther than 3 km from a modern village each contained approximately half as many sites as expected given their area.³⁰ The comparison dataset of randomly distributed points is weighted accordingly.

To study marketing, I rely on multivariate logistic regression analysis, which sorts observations into two, mutually exclusive categories. Therefore, the appropriate comparison dataset is not all locations that could have been chosen for settlement, but locations that – as far as we know – were not chosen. Non-settlements are locations distributed at random so as not to coincide with settlements. Because logistic regression analysis requires roughly similar numbers of settlements and non-settlements, the comparison dataset must be smaller than the one used in the univariate analysis. I therefore run the entire

³⁰ Weaverdyck 2016, op. cit. (n. 13), 125–129.

FIGURE 12.4 Schematic representation of the statistical analytical method. Rectangles represent variables and values used as inputs to and outputs of analytical processes, represented by circles

multivariate analysis five times using different sets of non-settlements. Results that are consistent across these datasets reflect the impact of the settlements rather than the varying non-settlements.

After the various models are represented digitally, and the variables measured, I apply a multi-step process of statistical analysis (fig. 12.4). First, I compare the prevalence of various environmental variables within settlement territories to a comparison dataset. The Kolmogorov-Smirnov (K-S) test identifies variables that differ significantly between the two datasets. Vargha-Delaney's A statistic (V-D A) shows the size and direction of the difference by estimating the likelihood that a randomly selected case from one dataset (settlements) will have a higher value of a certain variable than a randomly selected case from another dataset (the area as a whole). High values of V-D A indicate that most settlement territories contain more of a certain landscape feature than the comparison dataset, and low values mean the opposite.

In the next step, I use a multivariate technique, because it seems unlikely that rural inhabitants of the ancient world would prioritize access to markets

over basic productivity. Multivariate analysis allows me to control for the landscape features influencing production when I assess the importance of proximity to market centers. I select the environmental variables that were identified as most significant by the K-S test and combine them into a smaller set of composite variables using Principle Component Analysis because the environmental variables are often correlated with each other. These Principal Components are used to create a logistic regression model that attempts to distinguish between locations chosen for settlement and those that weren't on the basis of environmental variables alone. The resulting model is called the baseline model and has a certain level of error, quantified as the Root Mean Square Error or RMSE. The lower the RMSE, the better the model fits the data. Next, I calculate a second model using the same environmental variables but with the addition of an MP variable. If the MP variable improves model performance relative to the baseline model, we might be able to infer the impact market potential had on settlement locations and conclude that people traveled frequently to these market places. If the MP variable including forts improves model performance more than the one without them, this would suggest that people saw forts as part of their market system.

It is important to keep in mind that statistical analysis like this does not produce answers, but figures that summarize and quantify aspects of data that are otherwise opaque. Like an excavator's trowel, it is a tool that produces evidence, which must be interpreted. This analysis identifies overarching trends that are common to most rural settlements in a dataset. Diversity in the way that people perceived and interacted with the landscape will mute the statistical significance of the results, so the method is well-suited to understanding generalized, underlying processes.

3 Case Studies

The Lower Rhine and Lower Danube frontiers are both riverine frontiers with a linear arrangement of military forts along the banks. Both areas also contain one legionary fortress and several auxiliary forts. They differ in their history of occupation. The Lower Rhine was heavily militarized during the Julio-Claudian and Flavian periods, after which the number of soldiers was reduced. The Lower Danube was first occupied under Claudius and was not heavily fortified until the Flavian and Antonine periods. Both areas experienced violence in the 3rd c. and efforts at pacification by the Constantinian emperors during the 4th c., although success came earlier in the Lower Danube than the Lower Rhine. The power of the Roman Empire was challenged in both areas again in

the late 4th c. and early 5th c., but in the Lower Danube, the state continuously attempted to reestablish control throughout the 5th c. and 6th c., whereas it abandoned the Lower Rhine.³¹

The landscapes also differed. Both study areas contain enough local variation that they were each divided into analytical zones to maximize environmental homogeneity. In the Lower Rhine, the eastern zone contains large areas of sandy soil interspersed with levees while in the central zone, the levees are surrounded by floodplains and peat land. The western zone is unsuitable for analysis because large parts of it were uninhabitable. The major centers in this area – Oppidum Batavorum followed by Ulpia Noviomagus and the legionary fortresses of the Augustan and Flavian periods – were found at Nijmegen in the eastern zone. The Lower Danube study area is divided by the river Yantra, which flows along a fault line. To the west, the lower land contains gentle hills and broad valleys. The eastern part is uplifted, undulates irregularly, and is incised by deep river gorges. Major centers here are the legionary fortress and city at Novae and the city of Nicopolis ad Istrum.

4 Results

The graphs below show the V-D A statistic for variables identified as significant by the K-S test in at least one time period ($p < 0.05$ indicated by squares, $p < 0.10$ indicated by circles). For ease of interpretation, 0.5 has been subtracted from the A statistic so that values above zero indicate the variable was favored, while those below zero indicate avoidance.

We begin with the examination of agricultural intensification in the Lower Rhine region (Figs 12.5 and 12.6). First, the strength and stability of landscape preferences remain consistent over time. Most landforms analyzed showed significant differences in prevalence between settlement territories and the study area as a whole in most time periods. Levees were consistently favored, and the marginal landforms (floodplains, peat, and fresh water in the central zone, sands and fluvial terraces in the eastern zone) were also consistently avoided throughout antiquity. However, there is some variation. In particular, the preferences for low levees in the central zone and high levees in the eastern zone increased in the Early Roman A period, suggesting arable land was more highly valued in this period than it was in the Late Iron Age.

31 Weaverdyck 2016, op. cit. (n. 13), 69–77 for the Lower Danube; W.J.H. Willems, *Romans and Batavians: A Regional Study in the Dutch Eastern River Area* (Amsterdam 1986) for the Lower Rhine.

FIGURE 12.5 The relative prevalence of landforms in settlement territories in the central zone of the Lower Rhine. Periods when the prevalence of the landform is statistically significantly different from the comparison dataset are marked with a square ($p < 0.05$) or a circle ($p < 0.10$)

In the Lower Danube, perceptions of the landscape varied more across time but are also subtler (Figs 12.7 and 12.8). Fewer variables show statistically significant differences. This could be the result of a smaller sample size, a greater diversity of perspectives on the landscape surrounding settlements, or a less-constrained set of options as compared to the Lower Rhine. Nevertheless, some conclusions are possible. In the western zone, gentle hill slopes became more attractive in the mid-Roman period than they were in the pre-Roman period,

FIGURE 12.6 The relative prevalence of landforms in settlement territories in the eastern zone of the Lower Rhine. Periods when the prevalence of the landform is statistically significantly different from the comparison dataset are marked with a square ($p < 0.05$) or a circle ($p < 0.10$)

and valleys and upper slopes of hills became less attractive (the number of Early Roman sites is too small to analyze). Roman agronomists recommend gently sloping land for grain production because it drains well but is fairly easy to plow, while valleys can become waterlogged and upper slopes are exposed to wind. In the Late Roman period (4th c.), these preferences are less acute. In the eastern zone, settlements show no clear preferences in the mid-Roman period, but in the Late Roman period they favor gentle hillsides, as their eastern neighbors had before. Thus, there is some evidence for agricultural intensification in the Roman Lower Danube, but it occurred earlier in the zone west of the Yantra and later in the zone to the east.

FIGURE 12.7 The relative prevalence of topographic landforms in settlement territories in the western zone of the Lower Danube. Periods when the prevalence of the landform is statistically significantly different from the comparison dataset are marked with a square ($p < 0.05$) or a circle ($p < 0.10$)

The clearest locational tendencies in the Lower Danube area are exhibited by the Late Antique (5th–6th c. CE) settlements of the eastern zone, and they are the polar opposite of what came before. In a dramatic shift, gentle hillsides fall out of favor and people prioritize valleys, ridges, upper slopes, and steep hillsides. The same shift in priorities is visible in the western zone, but the preferences are less significant. These landscape features are not conducive to agriculture, but they are good for defense. The rivers flowing through the eastern zone of the Lower Danube incise steep, meandering valleys into the bedrock, producing defensible promontories surrounded by cliffs. The settlements studied here were not fortified themselves, but they achieved a measure of security by ensuring that defensible locations were close by. For the inhabitants of the Lower Danube in Late Antiquity, the overriding priority in choosing a place to live was no longer agricultural production, but security. This was a landscape shaped by fear.

The economic context of the militarized frontier and, in the Lower Danube, the insecurity of the 5th and 6th c. affected how people perceived the landscapes surrounding their settlements, but how did they perceive the auxiliary

FIGURE 12.8 The relative prevalence of topographic landforms in settlement territories in the eastern zone of the Lower Danube. Periods when the prevalence of the landform is statistically significantly different from the comparison dataset are marked with a square ($p < 0.05$) or a circle ($p < 0.10$)

forts themselves? The tables below (Tab. 12.2 and 12.3) present information about three statistics from the comparative multivariate modeling process. The number is the improvement in model performance attributable to the Market Potential variable. This is calculated as a percentage of the baseline Root Mean Square Error. The larger improvement is written in bold. Within a logistic regression model, each variable has a p-value indicating the statistical significance of its contribution to the overall model. MP variables with a p-value less than 0.1 are starred. Finally, each variable also has a coefficient, indicating the strength and direction of its contribution to the model. When the MP variable's coefficient is negative – indicating that the chance of a location being a settlement actually decreases as market potential increases – I've bracketed it in parentheses. The five rows represent the five different sets of non-settlements used.

TABLE 12.2 Improvement over baseline model from the addition of an MP variable in the Lower Rhine area

Without forts		With forts	Without forts		With forts
Early Roman A					
Central zone	0.01%	0.07%	Eastern zone	0.00%	(0.00%)
	0.01%	0.00%		0.30%	0.18%
	(0.15%)	(0.13%)		0.00%	(0.00%)
	(0.06%)	(0.02%)		0.27%	0.18%
	0.01%	0.04%		(0.00%)	(0.02%)
Early Roman B					
Central zone	(0.21%)	(0.01%)	Eastern zone	0.01%	(0.00%)
	(0.82%)*	(0.48%)*		(0.00%)	(0.00%)
	(0.04%)	0.01%		0.68%*	0.42%*
	0.01%	0.06%		0.07%	0.03%
	(0.01%)	0.15%		0.24%	(0.01%)
Middle Roman A					
Central zone	(0.08%)	(0.07%)	Eastern zone	0.20%	0.22%
	0.15%	0.06%		0.47%*	0.35%*
	(0.00%)	0.06%		0.04%	0.05%
	(0.04%)	0.08%		0.73%*	0.46%*
	(0.04%)	(0.03%)		1.02%*	1.11%*
Middle Roman B					
Central zone	(0.04%)	(0.13%)	Eastern zone	0.25%	0.30%
	(0.12%)	(0.08%)		0.52%*	0.24%
	0.02%	0.02%		0.17%	0.23%
	0.00%	0.00%		1.80%*	2.07%*
	0.07%	0.04%		0.69%*	0.59%*
Late Roman A					
Central zone	0.01%	(0.00%)	Eastern zone	0.42%	0.65%*
	(0.00%)	(0.00%)		0.21%	0.65%*
	(0.15%)	(0.11%)		0.00%	0.01%
	(-0.01%)	(-0.01%)		(0.00%)	0.04%
	0.11%	0.08%		(0.02%)	0.02%

TABLE 12.2 Improvement over baseline model from the addition of an MP variable (*cont.*)

Without forts		With forts	Without forts		With forts
Late Roman B					
Central zone	(0.01%)	(0.08%)	Eastern zone	0.94%*	1.38%*
	(0.12%)	(0.15%)		0.60%*	0.41%
	(0.03%)	(0.01%)		0.61%*	0.87%*
	(−0.02%)	(−0.03%)		0.20%	0.45%*
	(0.17%)	(0.23%)		0.74%*	1.02%*

We begin again with the Lower Rhine. The first statistically significant MP variables appear in the Early Roman B period. In the eastern zone, the MP variable without auxiliary forts improves model performance more than the one that includes them four out of five times, and one of these is statistically significant. In the central zone, one combination produces significant MP variables, and here the variable without forts again performs best, but with a negative coefficient. When the MP variable including forts performs best, the coefficient is positive. This would seem to suggest that settlements in the eastern zone were attracted to civilian market centers but not forts, while those in the central zone might have avoided civilian market centers, but may have been attracted to some forts. To understand this result, it helps to visualize the two MP variables along with settlements and non-settlements (fig. 12.9). In the map on the left, showing the MP variable that excludes forts, there are two broad patches of high values, and these mostly contain non-settlements. When forts are included in the MP variable, as in the map on the right, the northern patch extends to cover a cluster of settlements. In the former case, high MP values are primarily associated with non-settlements, whereas in the latter, both settlements and non-settlements have high MP values, making the variable less useful for distinguishing between the two. This result suggests that the fort at De Meern, Hoge Woerd I might have been seen as an attractive center at this time.

In the Middle Roman A and B periods, MP variables are more often significant in the eastern zone, but never in the central zone. Settlements in the east seem to favor proximity to markets but, since neither variable consistently outperforms the other, it is difficult to say how they viewed forts. The results are clearer in the Late Roman periods. In the eastern zone, the MP variable with forts outperforms the one without every time in the Late Roman A period and four times in the Late Roman B period, and they are often statistically significant. The market centers in the central zone did not attract settlements in the

FIGURE 12.9 Early Roman B MP variables in the central zone of the Lower Rhine study area. A: MP variable containing only civilian centers. B: MP variable containing civilian centers and forts

same way; in most cases, the coefficients were negative, although the variables were never significant.

TABLE 12.3 Improvement over baseline model from the addition of an MP variable in the Lower Danube area

Without forts		With forts	Without forts		With forts
Middle Roman					
Western zone	0.30%	0.16%	Eastern zone	0.00%	0.18%
	0.01%	(−0.01%)		(0.01%)	(0.03%)
	0.37%	0.19%		0.01%	0.59%
	0.38%	0.18%		(0.00%)	0.00%
	0.02%	(−0.02%)		0.25%	0.60%
Late Roman					
Western zone	0.33%	0.06%	Eastern zone	0.95%	0.19%
	0.18%	(0.00%)		1.30%	0.53%
	0.93%	0.02%		0.70%	1.23%
	0.44%	(0.02%)		0.77%	0.31%
	0.80%	(0.00%)		1.88%	1.14%

In the Lower Danube, no MP variable was ever significant, probably a result of the sparser data as compared to the Lower Rhine. At the same time, the relative performance of MP variables was more consistent. In the Middle Roman period in the western zone, the variable without forts performed best, while in the eastern zone, closer to the frontier, the one with forts performed best. In the Late Roman period, though, the variable without forts performed best in both zones, with a single exception in the eastern zone. Given the lack of statistical significance and the very small size of the improvement, we should treat these results with caution. Nevertheless, they do seem to suggest that auxiliary forts might have been attractive to some settlements in the eastern zone in the 2nd to 3rd c. but not in the 4th c.

5 Conclusion

This analysis shows that there is no definitive answer as to whether people living in the northern frontier zone saw Roman auxiliary forts as market places according to the models and data sets used. In some times and places, some forts did attract settlement and therefore probably functioned as markets, in other places they did not. In the middle of the 1st c. CE, the people in the central zone of the Lower Rhine probably sold their goods at at least one fort, but their neighbors in the eastern zone did not. Similarly, in the eastern zone of the Lower Danube, forts functioned as markets in the mid-Roman period, but not in the late Roman period. This means that our categorization of these places as 'auxiliary forts' is inadequate for economic questions. 'Auxiliary fort' is itself a model of an ancient place designed to highlight its role in the Roman military structure, but it obscures variation in the meaning that such a place could hold for people living in the countryside around it. The economic roles of auxiliary forts must be examined on a case-by-case basis.

The investigation of agricultural intensification has also demonstrated the complexity of the Empire's impact on landscapes. There is indeed some evidence that people generally preferred to settle in locations where they could access the affordance of good agricultural land. Levees were more attractive to the people living in the Lower Rhine area during the earliest phase of Roman rule than they had been during the Late Iron Age. In the Lower Danube, gently sloping hills took on greater significance, but the timing of this change differed between the eastern and western zones of the study area. The impacts of Rome on landscapes could vary even on a local scale. The most dramatic impact of the Empire on landscapes, however, came not as a result of occupation, but as

a result of collapse. In Late Antiquity, especially from the late 4th c., the Lower Danube was subject to wars, and Roman imperial officials adopted a different perspective on this landscape than they had before. In the late 3rd and early 4th c., emperors invested heavily in frontier defense along the river, and tetrarchic building inscriptions explicitly emphasize their intentions to bring peace and security.³² But during the Gothic wars of the 370s, the Roman government abandoned the countryside of the Danubian plain to the Goths. After this, the Empire invested in fortifications at various places, including supply depots set back from the river itself.³³ It seems the Empire's strategy was focused on controlling nodes within a military network rather than defending the territory of the Lower Danube plain. The people living in the countryside responded by living in locations that afforded them the opportunity of flight and defense. In the 4th c., the Lower Danube was a landscape of production, but in the 5th and 6th, it was a landscape of fear.

Glossary

K-S test The Kolmogorov-Smirnov test is a statistical method of determining if two sets of continuous, numerical values are drawn from the same population. It is useful in that it can compare datasets with very different sizes.

Logistic Regression Analysis A statistical method that creates a model predicting a dependent variable on the basis of multiple independent variables. It is useful because the independent variables can be continuous numbers, categories, or other types, and it can predict a binary dependent variable.

MP Market Potential is a quantitative representation of the marketing opportunities available at any location within a market system. It is the sum of the purchasing power of each market divided by the distance to that market from the location in question.

Principle Component Analysis A technique to summarize multivariate data using a smaller set of variables. By design, the resulting principal components are uncorrelated with each other.

RMSE The Root Mean Square Error is a measure of goodness of fit between a model and a dataset. It is the square root of the sum of the squared differences

32 A. Poulter, 'The transition to Late Antiquity', in A. Poulter (ed.), *The Transition to Late Antiquity on the Danube and Beyond* (Oxford 2007), 30.

33 Poulter 2019, op. cit. (n. 29).

between the actual value of each data point and the value predicted by the model.

V-D A Vargha and Delaney's A statistic is a statistical measure of effect size. Given two sets of data with continuous values, it is the likelihood that a value randomly selected from one set will be higher than a value randomly selected from the other set.