Understanding the Central Place Functions of Roman Forts through Landscapes

Eli J. S. Weaverdyck

Introduction

This paper is an investigation of the central place functions of Roman auxiliary forts, using the Lower Rhine frontier as a case study.[1] Specifically, it seeks evidence for market functions in the spatial distribution of the rural settlements that surround them. It is less concerned with the retail marketing of urban goods and services that Christaller was concerned with when he formulated Central Place Theory, and more with the question of whether these numerous, small forts functioned as market places for the sale and exchange of rural produce.[2] This question has important consequences for our understanding of the economic impact of the Roman army.

In the first and early second centuries CE, the Roman Empire lined the Rhine and the Danube with large, legionary fortresses and numerous smaller, auxiliary forts. In comparison to the Mediterranean basin, much of this area had hitherto been sparsely populated and little-urbanized, so this fortified frontier zone caused a rather sudden jump in the population of many of these areas. What's more, the new immigrants were generally consumers rather than producers of food. Documentary and archaeological evidence demonstrate that these forts and fortresses, along with the civilian settlements that grew up beside them, were densely populated, socially diverse places with access to long-distance exchange networks, coined money, and manufactured goods. In these ways they resemble the towns of the Mediterranean basin.[3]

The Roman town was both a node in long-distance exchange networks and a central place in local exchange networks. Archaeological and historical evidence shows that forts were certainly tied into long-distance networks, but their role in local exchange is less clear. While they concentrated wealth and contained many consumers, a significant portion of their subsistence needs were organized through centrally directed networks and there could be significant social and cultural divides between the inhabitants of the forts and the countryside.

In many cases it has been observed that the presence of the fortified frontier coincides with evidence for increased production in the countryside and so, it is concluded, the army must have stimulated the economy.[4] This is certainly true in a general way, but it is important to ask how this surplus actually got to the consumers in the army bases because this has important social consequences for the population of the region as a whole.[5] If military demands were being met primarily from large scale producers, this would have increased economic inequality; if it were being met by people who could combine the surplus of many small scale producers, the ones bulking the cargo would have captured a significant share of any profits to be made. If the small-scale

Published in: Martin Bentz – Michael Heinzelmann (Eds.), Sessions 6–8, Single Contributions. Archaeology and Economy in the Ancient World 55 (Heidelberg, Propylaeum 2023) 391–403. DOI: *https://doi.org/10.11588/propylaeum.1035.c14102*

producers were selling their goods directly in the forts, on the other hand, they would have maintained their independence and retained the profits.

If forts did perform market functions, there is good reason to think that they might have been particularly attractive to small-scale producers. First, forts were often closely spaced, providing multiple marketing opportunities and enhancing the bargaining power of the producer. Second, the soldiers' ration consisted mostly of grain, which was supplied by the unit, but there was a market for supplements like fruits, vegetables, and eggs, as demonstrated by the Vindolanda tablets.[6] Paul Erdkamp has argued that, because of the relatively high labor and low capital inputs, small-scale producers are less disadvantaged in market gardening than in grain production, which requires investments in storage to make it profitable. It may not be a coincidence, then, that whenever ancient literary sources depict peasants engaged in marketing, they are selling vegetables.[7]

This type of economic strategy can be detected through location analysis of rural settlements and their relationship to central places. Because transportation costs are relatively high, market gardening should be concentrated close to market centers, as predicted by Von Thünen.[8] Grain production, on the other hand, has lower transportation costs because it can be stored and transported in fewer trips, so it is less sensitive to the location of the market. Livestock has even lower transportation costs. Von Thünen described the impact of a single market on the economic geography of its hinterland. It is likely, however, that access to multiple market centers was advantageous, so proximity to all central places in the landscape will be measured using a Market Potential variable (see below).

A larger problem in implementing Von Thünen's model that is especially acute when dealing with ancient small-scale agriculture, is that producers did not live on an undifferentiated plane. Small-holders in antiquity usually relied on their own production for a large portion of their subsistence needs. The ability to sell a surplus would have been less important than the ability to produce enough to survive, so it would be unrealistic to expect the density of settlements in the Lower Rhine to simply decline with distance to markets without taking into account the productive capacity of the landscape. In order to identify the central place functions of forts, one must examine proximity to forts while controlling as many of the other factors that influenced rural settlement location as possible. In this case, a palaeogeographic reconstruction of the landscape represents those other factors.

Method

The method I developed to test the central place functions of auxiliary forts has two steps. First, I examine the territories within the immediate vicinity of settlements to inductively determine which environmental factors influenced settlement location.

I examine two sizes of territories: one with a 500 m radius, which has been identified as meaningful based on cluster analysis by Philip Verhagen and his team and which is a reasonable estimate for the maximum size of a small holding; the second has a radius of 1.5 km, which Michael Chisholm identified as the distance beyond which intensive labor inputs in fields becomes less likely.[9] I compare these territories to the territories around every inhabitable point in the study area. I measure the percentage of the territory covered by different environmental variables, then I use the Kolmogorov-Smirnov test to identify the variables whose abundance in settlement territories differs significantly from their abundance in the territories around all habitable locations, as well as Vargha and Delaney's A statistic to measure the size and direction of the difference.[10]

In the second stage of analysis I use logistic regression analysis to compare settlement territories to territories around non-sites, places where people could have settled, but did not. These are random points distributed so as to avoid overlap with settlements. This means that each chronological period has its own set of non-sites. The independent variables in the logistic regression analysis are principle components that combine the influential variables identified in the first step. This provides a baseline model that distinguishes settlements from non-sites purely on the basis of settlement territories. The model's accuracy is assessed using the Root Mean Square Error (RMSE). I then calculate a second model using as independent variables the same principal components as well as a Market Potential (MP) variable. If the second model's RMSE is lower than the baseline model, I conclude that market potential had an important influence on rural settlement patterns. I also take into account the sign of the MP variable coefficient and its significance in the logistic regression model.

The market potential (MP) variable is the key to understanding the role of forts. It not only allows one to take into account multiple market centers, it also allows one to test whether auxiliary forts should be included as market centers. Market Potential is a quantitative representation of marketing opportunities from a given location within a market system. Each market place is given a weight according to its purchasing power, population, or, in cases such as this where purchasing power and population are unknowable, estimated relative importance. The weight is then divided by the marketplace's distance from the location in question. Distance is calculated in terms of pedestrian travel time.[11] These quotients are calculated for all centers in a market system and summed to arrive at a single value for market potential.

I constructed two different market potential variables corresponding to different hypothesized relationships between auxiliary forts and the rural population. In both MP variables, cities were given the greatest weight of 25, civil settlements were given a weight of 5, and cult sites were given a weight of 1. In the MP variable corresponding to the hypothesis that auxiliary forts acted as markets similar to small towns, the forts were given a weight of 5. In the MP variable corresponding to the hypothesis that they were isolated from the countryside, they were given a weight of 0. A legion was stationed in the area twice. The Augustan period fortress was only briefly occupied and it was given a weight of 25 in the military and civilian MP variable. The Flavian period fortress was occupied longer and it was surrounded by a massive *canabae.* Together, the fortress and *canabae* are over twice the size of the nearby city. However, both were occupied for only half of the period in which they fall, so I gave the *canabae* a weight of 37.5 and the fortress a weight of 12.5 so that, in the military and civilian MP variable, they add up to 50. All of the weights are cumulative, so if a site contains both a fort and a civil settlement, the weight is 10 in the civilian and military MP variable.

One pitfall is that the model's results depend as much on the locations of non-sites as on settlements, so the multivariate stage of analysis is repeated five times with different sets of non-sites to identify spurious results. If one of the MP variables consistently improves model performance more than the other, and if the influence of that variable is statistically significant, that provides strong support for the hypothesis that that MP variable is a better approximation of the ancient marketing system than the other. By comparing multiple models that use the same production variables I can test for the influence of proximity to central places while accounting for the other factors influencing settlement location.

Data

The archaeological dataset was compiled as part of the project "Finding the Limits of the Limes", led by Philip Verhagen with Mark Groenhuijzen and Jamie Joyce, who have graciously shared it with me.[12] By using aoristic analysis and Monte Carlo simulation, they were able to assign a large number of rural settlements to specific time periods (table 1). The C and E in the table refer to central and eastern zones of the study area (see below). The environmental data come from a palaeogeographic reconstruction made by Mark Groenhuijzen following the method laid out by Marieke Van Dinter (fig. 1).[13]

Both univariate and multivariate analysis measure the influence of natural and social environmental factors on a group of settlements. If some settlements were responding to radically different environmental constraints than others, these could cancel each other out and become invisible in the analysis. Therefore, these constraints were homogenized as much as possible by subdividing the study area into zones. Philip Verhagen and his team conducted a cluster analysis of landscapes within 20 km of settlements that identified three broad regions: western, central, and eastern.[14] The western zone is unsuitable for this analysis because of the large areas of peat and the strong influence of fluvial action on the archaeological record. 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. Because no settlements in the eastern or central zone are found on peatland, I excluded peat from the habitable zone that forms the basis of comparison for the settlements.

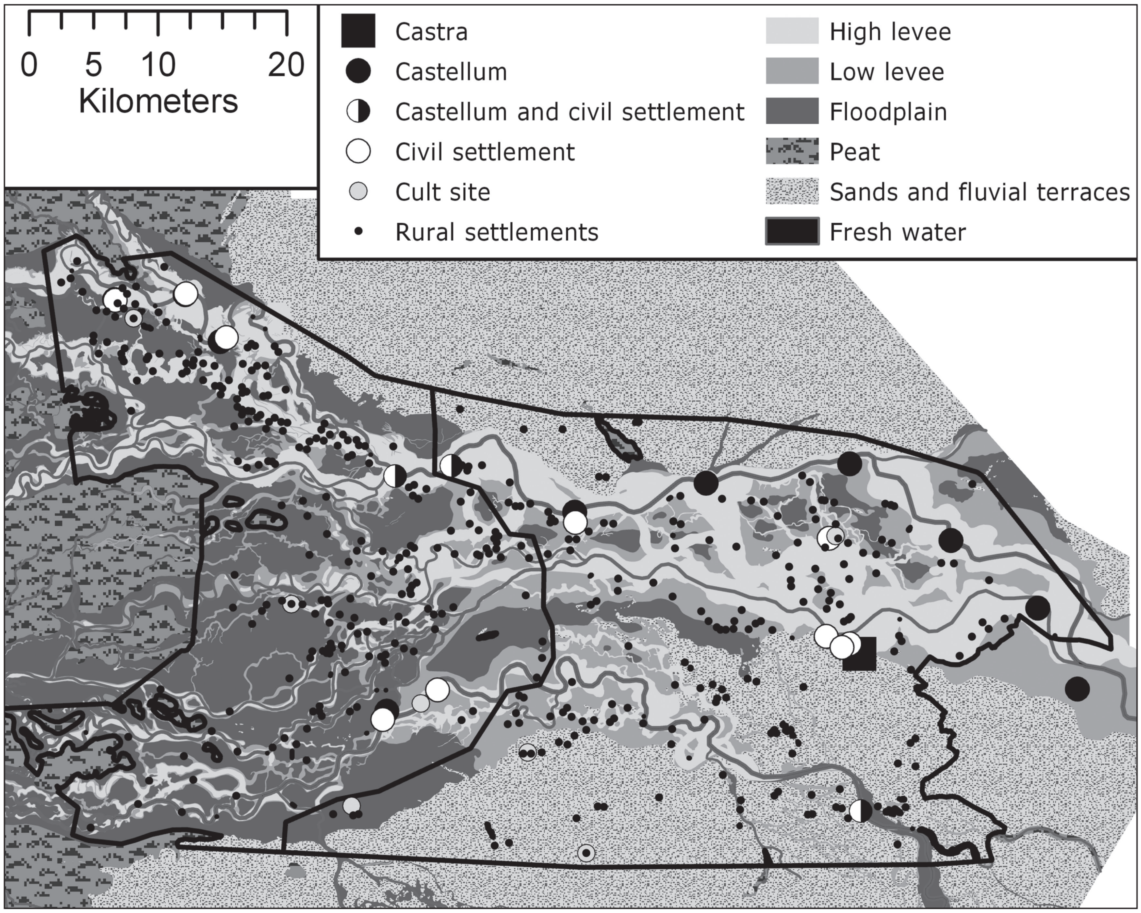

Fig. 1: The central and eastern zones of the study area with Middle Roman A period sites and palaeogeography.

Period	Date range	Sites		Rural settlements	
Late Iron Age	250–12 BCE	C: 141	E: 126	C: 137	E: 123
Early Roman A	12 BCE–25 CE	C: 138	E: 111	C: 131	E: 97
Early Roman B	25–70 CE	C: 163	E: 130	C: 153	E: 116
Middle Roman A	70–150 CE	C: 233	E: 197	C: 222	E: 177
Middle Roman B	150–270 CE	C: 248	E: 224	C: 237	E: 208
Late Roman A	270–350 CE	C: 158	E: 128	C: 153	E: 118
Late Roman B	350–450 CE	C: 176	E: 144	C: 170	E: 133

Table 1: Sites and rural settlements by chronological period in the central (C) and eastern (E) zones.

Results

Univariate analysis of the influence of land forms on settlement patterns revealed relatively stable trends over time (fig. 2). Levees were always favored. In the central zone, this came at the expense of floodplains, and in the eastern zone, it came at the expense of sands and fluvial terraces.

The baseline logistic regression models were only moderately successful at distinguishing settlements from non-sites on the basis of the landforms in their territories (fig. 3). Nevertheless, some diachronic trends emerge. RMSEs fall in the eastern zone between the Late Iron Age and the Early Roman A period. In both zones, they rise until the Mid-Roman periods before falling in in the Late Roman A and beginning to rise again in the Late Roman B. This is the same trend as observed in settlement numbers, suggesting that as population increased, settlement extended into more marginal areas that resemble non-sites in their territory profiles. Alternatively, factors other than the landforms present in settlement territories could have been influencing settlement location.

The addition of an MP variable only ever improves model performance slightly, but there are times when the improvement is significant and one MP variable consistently improves model performance (table 2). In the Early Roman B period, roughly 25–70 CE, the civilian MP variable consistently performs best with 1,500 m territories in the central zone, but the coefficient is negative. It seems that settlements are avoiding central places, but perhaps avoiding forts less. In the eastern zone, the civilian MP variable performs best again, but coefficients are positive.

In the period between 70 CE and the mid-second century (middle Roman A), the civilian MP variable consistently performs best in the eastern zone with positive coefficients, and it performs best in the central zone with negative coefficients, mostly with 1,500 m territories.

The middle Roman B period is confusing because the improvements in the eastern zone are greater here than any other period or place, but which MP variable generates the best improvement is not totally consistent.

The results from the period following the collapse in the mid-third century are generally insignificant and inconsistent, but there are more significant results in the recovery period running from the mid-fourth to mid-fifth century. Here again we see significant improvements from the addition of MP variables in the eastern zone, but inconsistency in which MP variable most improves model performance. In the central zone, the civilian and military MP variable almost always performs best, but again the coefficients are negative.

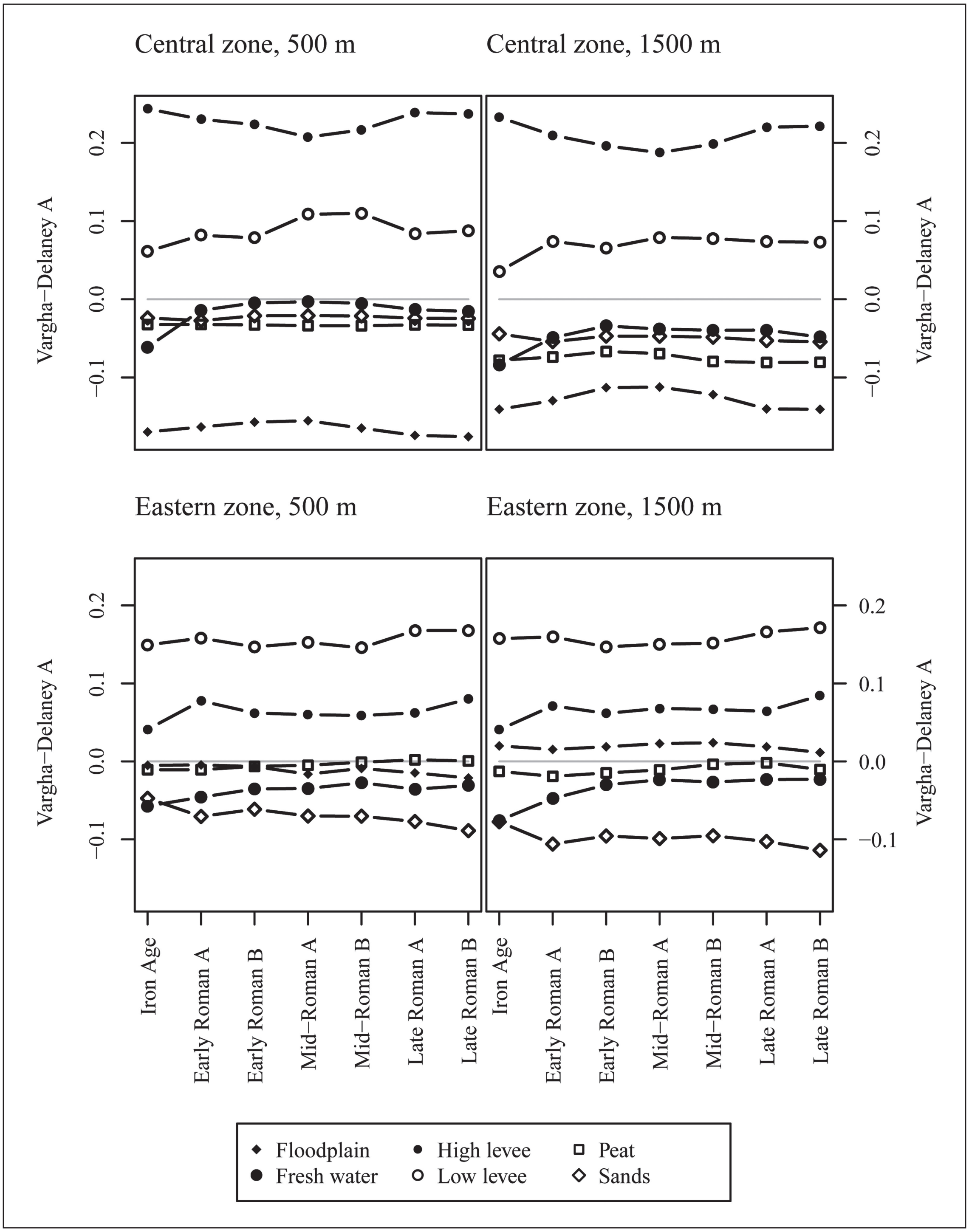

Fig. 2: Vargha-Delaney A statistics showing the difference between settlement territories and the entire habitable zone in the prevalence of each landform. 0.5 has been subtracted from each statistic to make the results more readily interpretable.

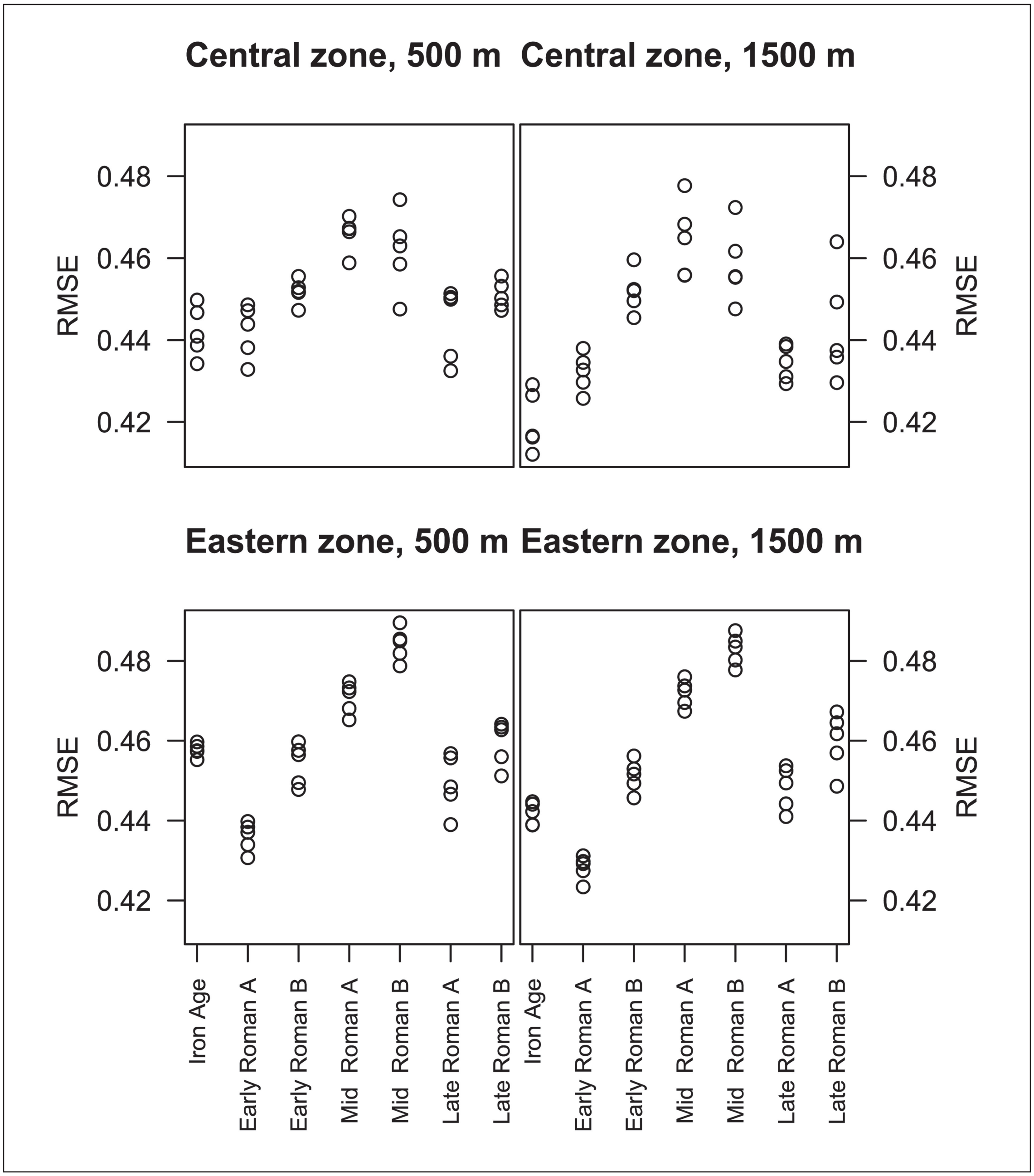

Fig. 3: RMSEs of baseline logistic regression models.

	consistent, significant improvement			
Period	Central zone		Eastern zone	
	500 m	1,500 m	500 m	1,500 m
Late Late Iron Age	none significant	none significant	consistent Civ (4, +)	consistent Civ (3, +)
Early Roman A	inconsistent, none significant	inconsistent, none significant	consistent Civ (2, +)	consistent Civ (1, +)
Early Roman B	inconsistent, Civ (1, −)	consistent Civ (3, −)	consistent Civ (1, +)	consistent Civ (2, +)
Middle Roman A	inconsistent, none significant	consistent Civ (0, −)	consistent Civ (3, +)	consistent Civ (3, +)
Middle Roman B	inconsistent, none significant	inconsistent, none significant	inconsistent, Civ (3, +)	inconsistent, Civ (3, +)
Late Roman A	inconsistent, none significant	inconsistent, none significant	inconsistent, Civ (1, +), Civ & Mil (1, +)	inconsistent, Civ (1, +), Civ & Mil (1, +)
Late Roman B	consistent Civ & Mil (2, −)	inconsistent, Civ (1, −), Civ & Mil (3, −)	inconsistent, Civ (2, +), Civ & Mil (3, +)	inconsistent, Civ (2, +), Civ & Mil (3, +)

Table 2: Summary of model improvement through the addition of MP variables to the baseline logistic regression model. Each cell contains four pieces of information: whether or not one variable consistently improved model performance more than the other; which variable most improved model performance; the number of times out of five separate runs that the variable was statistically significant in the logistic regression model; and the sign of the coefficient.

Discussion

In the eastern zone, the civilian MP variable performs best with positive coefficients in the Early Roman B and Middle Roman A periods; in later periods, both MP variables significantly improve model performance. Therefore, we can conclude that rural settlements are sensitive to the proximity of central places, but there is no strong evidence to suggest that those central places included forts.

In the central zone, the picture is more complicated because the coefficients are so often negative. Visualizing the two market potential variables side-by-side provides some clarity. Figure 4 depicts the central zone in the early Roman B period, showing settlements and the set of non-sites for which the civilian MP variable most improved performance. On the left side, these overlie the civilian MP variable. Five zones of high market potential are visible and these are generally filled with non-sites; high market potential values are associated almost exclusively with non-sites in this model. On the right, which shows the civilian and military MP variable, a sixth zone of high market potential has been added in the northwest around the fort at De Meern. This area is filled with settlements. In this case, high MP values are associated with both settlements and non-sites, so the model is less able to distinguish between them. From this it looks like the fort at De Meern was attracting settlement in a way that civilian settlements, even those around other forts, were not.

With this one exception, it seems that forts did not produce marketing opportunities that were seized by small-scale producers in such a way as to affect the pattern of rural settlement. One should not exclude the possibility of small producers selling livestock directly at the forts, but this analysis supports the idea that military demand was primarily met by large-scale producers who could gather and store grain for infrequent

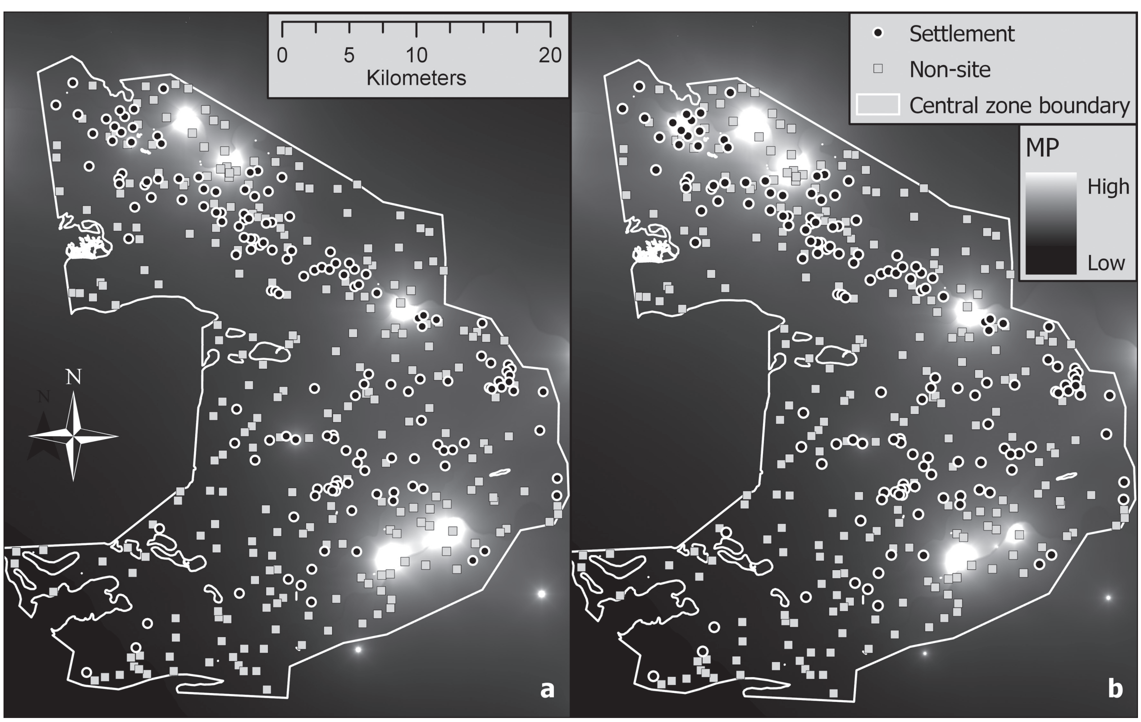

Fig. 4: Comparison of civilian and civilian and military MP variables in the early Roman B period.

transportation, or middlemen, perhaps based in the city of Ulpia Noviomagus, which does seem to have attracted rural settlement in the eastern zone.

Conclusion

The archaeological evidence for increases in wealth and consumption in frontier zones following the Roman occupation suggests that the military presence did stimulate the economy. More was produced and exchanged than before. This analysis of rural settlement patterns, however, adds nuance to that general conclusion. The results presented here suggest that most auxiliary forts were not functioning as market places in a way that enticed people to farm the land in their vicinity. Despite their wealth and non-agricultural population, they did not perform this central place function.

As explained above, had they been market places, the frontier could have formed a landscape of opportunity for small-scale producers. Because they were not market places, it seems more likely that the economic stimulus provided by the military was channeled through cities and towns, places where cargos could be combined by middlemen for efficient distribution to the forts. Some producers might have sold directly to auxiliary forts, but either they did so without minimizing transportation costs – suggesting the sale of livestock or grain – or there were so few who did minimize transportation costs to these places that they left no impact on the overall settlement pattern.

As with any individual technique, the process of comparative modeling does not produce all of the answers, but it is helpful in understanding the relationships between larger population centers and the countryside as well as suggesting ways that goods did or did not circulate in the area.

Notes

[1] This is a lightly edited version of the presentation delivered at the 19th International Congress of Classical Archaeology. It summarizes research that is more fully published elsewhere: Weaverdyck 2019. I am grateful to the organizers of the session "Central places and un-central landscapes," Giorgos Papantoniou and Thanasis Vionis, for allowing me to present my work.

[2] Christaller 1966.

[3] Sommer 1988; Allison 2013.

[4] Cherry 2007.

[5] Maaike Groot 2016 has examined this question using faunal remains.

[6] Whittaker 2002; Evers 2011.

[7] Erdkamp 2005.

[8] von Thünen 1966.

[9] Chisholm 1979; Verhagen et al. 2016.

[10] Vargha – Delaney 2000.

[11] Travel time was estimated using Groenhuijzen's procedure, which assigns a coefficient to each landform reflecting how difficult it is to traverse (Groenhuijzen – Verhagen 2017).

[12] Verhagen et al. 2016.

[13] van Dinter 2013.

[14] Verhagen et al. 2016.

Image Credits

Fig. 1: Weaverdyck 2019, fig. 1. – Fig. 2: Weaverdyck 2019, fig. 2. – Fig. 3: Weaverdyck 2019, fig. 3. – Fig. 3: Weaverdyck 2019, fig. 4. – Table 1: Weaverdyck 2019, tab. 1. – Table 2: Original.

References

Allison 2013
P. M. Allison, People and Spaces in Roman Military Bases (2013).

Cherry 2007
D. Cherry, The Frontier Zones, in: W. Scheidel – I. Morris – R. P. Saller (eds.), Cambridge Economic History of the Greco-Roman World (Cambridge 2007) 720–740.

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

Christaller 1966
W. Christaller, Central Places in Southern Germany, trans. by C. W. Baskin (Englewood Cliffs 1966).

van Dinter 2013
M. van Dinter, The Roman Limes in the Netherlands: How a Delta Landscape Determined the Location of the Military Structures, Netherlands Journal of Geosciences 92, 2013, 11–32. <https://doi.org/10.1017/S0016774600000251> (17. 08. 2019).

Erdkamp 2005
P. Erdkamp, The Grain Market in the Roman Empire: a Social, Political and Economic Study (Cambridge 2005).

Evers 2011
K. G. Evers, The Vindolanda Tablets and the Ancient Economy, BAR 544 (Oxford 2011).

Groenhuijzen – Verhagen 2017
M. R. Groenhuijzen – J. W. H. P. Verhagen, Comparing Network Construction Techniques in the Context of Local Transport Networks in the Dutch Part of the Roman Limes, Journal of Archaeological Science: Reports 15, 2017. <https://doi.org/10.1016/j.jasrep.2017.07.024> (17. 08. 2019).

Groot 2016
M. Groot, Livestock for Sale: Animal Husbandry in a Roman Frontier Zone: the Case Study of the Civitas Batavorum (2016).

Sommer 1988
C. S. Sommer, Kastellvicus und Kastell: Untersuchungen zum Zugmantel im Taunus und zu den Kastellvici in Obergermanien und Rätien, FuBerBadWürt 13, 1988, 457–707.
von Thünen 1966
J. H. von Thünen, Der isolierte Staat in Beziehung auf Landwirtschaft und Nationalökonomie (Darmstadt 1966).
Vargha – Delaney 2000
A. Vargha – H. D. Delaney, A Critique and Improvement of the CL Common Language Effect Size Statistics of McGraw and Wong, Journal of Educational and Behavioral Statistics 25, 2000, 101–132. <https://doi.org/10.3102/10769986025002101> (17. 08. 2019).
Verhagen et al. 2016
J. W. H. P. Verhagen – I. Vossen – M. R. Groenhuijzen – J. Joyce, 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, Journal of Archaeological Science: Reports 10, 2016, 309–321. <https://doi.org/10.1016/j.jasrep.2016.10.006> (17. 08. 2019).
Weaverdyck 2019
E. J. S. Weaverdyck, The Role of Forts in the Local Market System in the Lower Rhine: toward a Method of Multiple Hypothesis Testing through Comparative Modelling, in: P. Verhagen – J. Joyce – M. Groenhuijzen (eds.), Finding the Limits of the Limes: Modelling Demography, Economy and Transport on the Edge of the Roman Empire, Simulating the Past (Berlin 2019). <https://doi.org/10.1007/978-3-030-04576-0> (17. 08. 2019).
Whittaker 2002
C. R. Whittaker, Supplying the Army. Evidence from Vindolanda, in: P. Erdkamp (ed.), The Roman Army and the Economy (Amsterdam 2002).