BUILDING NEW EXPLANATIONS ABOUT ROMAN SETTLEMENT PATTERNS:

PREDICTIVE MODELLING IN NORTHERN GAUL

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Abstract
By employing a tailored methodology of predictive modelling, this paper uncovers factors influencing Roman farmers' decisions on where to settle in the Somme (modern department in northern France). Few studies have devoted efforts towards this goal, as the Somme displays a relatively smooth topography, giving the impression that its site location patterns were homogeneous. The results of this study indicate that the physical landscape did influence site location: rural settlements were more often located in flat areas or gentle valley slopes near rivers. Socio-economic factors, such as the accessibility of local markets, however, seem to hold even more influence over site location than the physical landscape, since the preference for well-connected areas appears for all types of farms. If all areas could be settled by Roman farmers, well-connected areas were therefore viewed as more suitable than others.

Keywords
Site location analysis, archaeological location models, Gallo-Roman archaeology, Somme, rural settlements

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Introduction

At the centre of the Roman world lay its countryside, both demographically and economically, as the vast majority of people lived as farmers on which depended the entire structure of the Roman economy. Paramount to the development of a Roman farm is its specific location, as evidenced through the treaties of the Latin agronomists, mentioning both environmental factors and socio-economic ones as important to the development of Mediterranean farms (Cato Agr. 1-2; Varro Rust. 1; Col. 1; Pallad. 1). In contrast, very few studies attempt to identify which factors influenced the location of rural settlements in northern Gaul, notably because of the relatively smooth landscape in the area (Ben Redjeb et al. 2005, 188). Relatively low relief encouraged the large-scale development of open-land grain farming in the Roman period. This is not only evidenced by rescue archaeology, but also by aerial and field surveys carried out between the 1960s and the late 1990s,

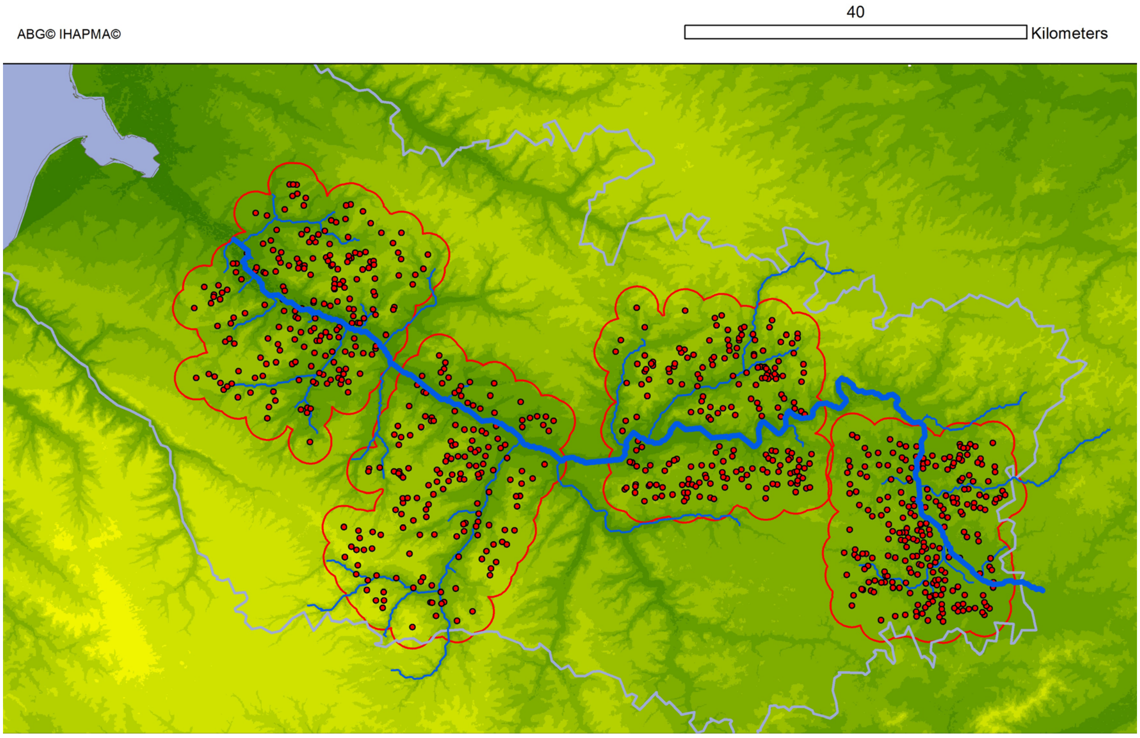

Figure 1. Micro-regions defined in the Somme department, with all rural settlements in red.

which have permitted the discovery and study of more than 2000 rural sites in the Somme department (Agache 1978; Bayard and Collart 1996; Bayard 2014; Ben Redjeb 2013, Reddé 2017).

This paper discusses variables, both environmental and socio-economic, that could have played a part in rural site locations of the Roman Somme. For this purpose I apply a specific framework employing predictive modelling. This technique – applied in archaeology since the 1970s – can be used to predict the potential location of undiscovered sites (Kohler et al. 1996; Kvamme 2006; Verhagen et al. 2010). It can also inform site location analyses, by confronting the modelled expectations with actual site distributions. Traditionally focused on purely environmental variables, predictive modelling now often includes social, economic and cultural factors in a non-deterministic approach, notably applied in case studies covering northeastern and southeastern Gaul (Verhagen et al. 2011; 2013; Nuninger et al. 2016; Nüsslein 2016; Stancic et al. 1999; Kvamme 2006, 21). The present study constitutes a continuation of the latter experiments and also the first application of archaeological predictive modelling in northern France. This paper takes into consideration specific socio-economic factors, which could have influenced human behaviour in site location (visibility, accessibility of socio-economic centres, proximity of Roman roads), without excluding the physical landscape as a set of potential variables, even where local variations are relatively gentle.

Spatial and chronological scope

The Somme department is a large area (6170 km^2), too large to be studied as a single entity, for it would render site location analyses inefficient due to a very heterogeneous dataset, as well as erase potential variations in the sub-regions. Therefore, this department had to be divided into four distinct micro-regions, totalling 2090 km^2 (fig.1). They were selected on

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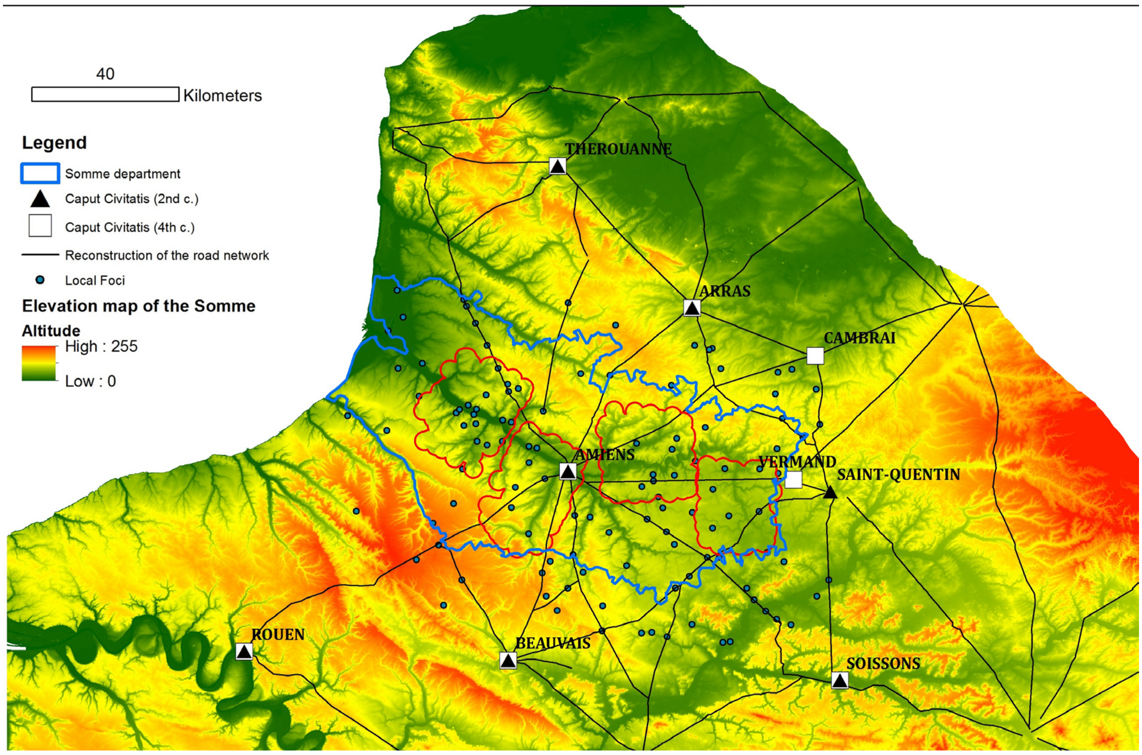

Figure 2. Contextual sites in Northern Gaul: capital cities (caput civitatis) and local markets (secondary agglomerations and sanctuaries).

the basis of three criteria: the availability of an important archaeological dataset, the quality of this dataset (whether it was generated by excavations or surveys) and the existence of a common element in all regions: the Somme River. A buffer area of 2500m was created around the rectangular sets of sites. These four regions differ by the differential ruggedness of their topography, the presence of meanders, their locations relative to different tributary rivers, and their proximity to the Roman city of Amiens (first three regions) or the city of Saint-Quentin (fourth region).

In terms of chronological boundaries, this study encompasses the bulk of the Roman Imperial period, from the second half of the first century CE to the end of the fourth century CE. The starting period thus excludes "transitional" settlements, which are not yet fully understood and display important ruptures with both the Late Iron Age and the Imperial period. The end of the studied timeframe is marked by an extreme rate of abandonment of all rural settlements, displaying no continuity with the following settlement period in the end of the fifth century CE. The very high continuity of settlement patterns during this interval of 350 years permitted the evaluation of site location choices on a regional scale. Indeed, palaeoenvironmental analyses emphasize that both the physical landscape and land-use predominantly indicate continuity rather than rupture (Lepetz et al. 2003, 28; Matterne 2001, Wightman 1985, 4-5). Furthermore, the near-entirety of rural settlements was created before the middle of the second century CE, with only four sites being built later.

The archaeological dataset

The 822 rural settlements contained in the four micro-regions are densely and seemingly homogeneously distributed. Despite the wide development of preventive archaeology, only 97 of these sites were excavated, inducing a certain coarseness in the qualitative attributes of the dataset.

Following the recent classification of rural settlements produced by Dutch, Belgian and French scholars (Deru 2012; Roymans et al. 2011, 2; Habermehl 2013; 2011, 62; Ferdière et al. 2010), many sites of this dataset can be categorised in three morphological groups: 61 post-built farms, 729 stone-built farms and 32 villas. Post-built farms are diverse settlements only employing wooden substructures that are well represented in recent excavations. Nonetheless, stone-built farms are clearly dominant, representing 89% of all sites. Their spatial organisation and architecture are often inspired by those of villas, which are very large stone-built farms with several production buildings and a residential complex comprising at least 15 rooms, heating systems or other amenities.

The 71 other non-rural settlements constitute nodes towards which rural settlements could be attracted: the cities on and around the Somme, the sanctuaries, the secondary agglomerations and the market-villages/*vici* (fig.2).

Methods

My approach involves archaeological location modelling: 'understanding past land use or what can be called site location processes' (Whitley 2004, 2). No single framework is employed by all scholars, as each one follows different aims and theoretical assumptions. This study's methodology shares much in common with the goals and tools employed by the collaborators of the 'Introducing the Human (f)Actor in Predictive Modelling for Archaeology' project (IHAPMA), which emphasises the socio-cultural factors in site location modelling (Verhagen et al. 2011; 2013; Nuninger et al. 2016; Nüsslein 2016, Bertoncello et al. 2008). Nevertheless, while the latter employed data-derived models, the framework of this study revolves around theory-driven models: hypotheses are the basis of models while the independent variables (rural settlements) are solely employed during the evaluation of model accuracy (fig.3).

The conceptual phase of this approach includes the formulation of a specific research question, such as the following: Are rural settlements generally located in areas with easy access to local markets? A subsequent hypothesis fits this question, which can be translated into a formula used in the model: Rural settlements are expected to be located near local markets (i.e. higher market accessibility = higher site frequency).

During the technical phase, models of each variable and their potential combinations are created with a Geographical Information System (ESRI's ArcGIS© v.10.4). They form univariate models of every variable here presented. These maps are then manually reclassified in areas of high, medium, and low expectations of site frequency, following the starting hypothesis. As different maps are computed for each micro-region, hypothesis, chronological subdivision, or settlement type, several hundreds of sub-models result from this phase. The reclassified models are visually inspected to assert their conformation to the hypothesis, and only the univariate model of path distance to rivers was further reclassified, as was my hypothesis. In no way does any model reach the optimal correlation with the data-set, for it would require a data-based modelling framework. Only the direct spatialization of the formal hypotheses can therefore be asserted.

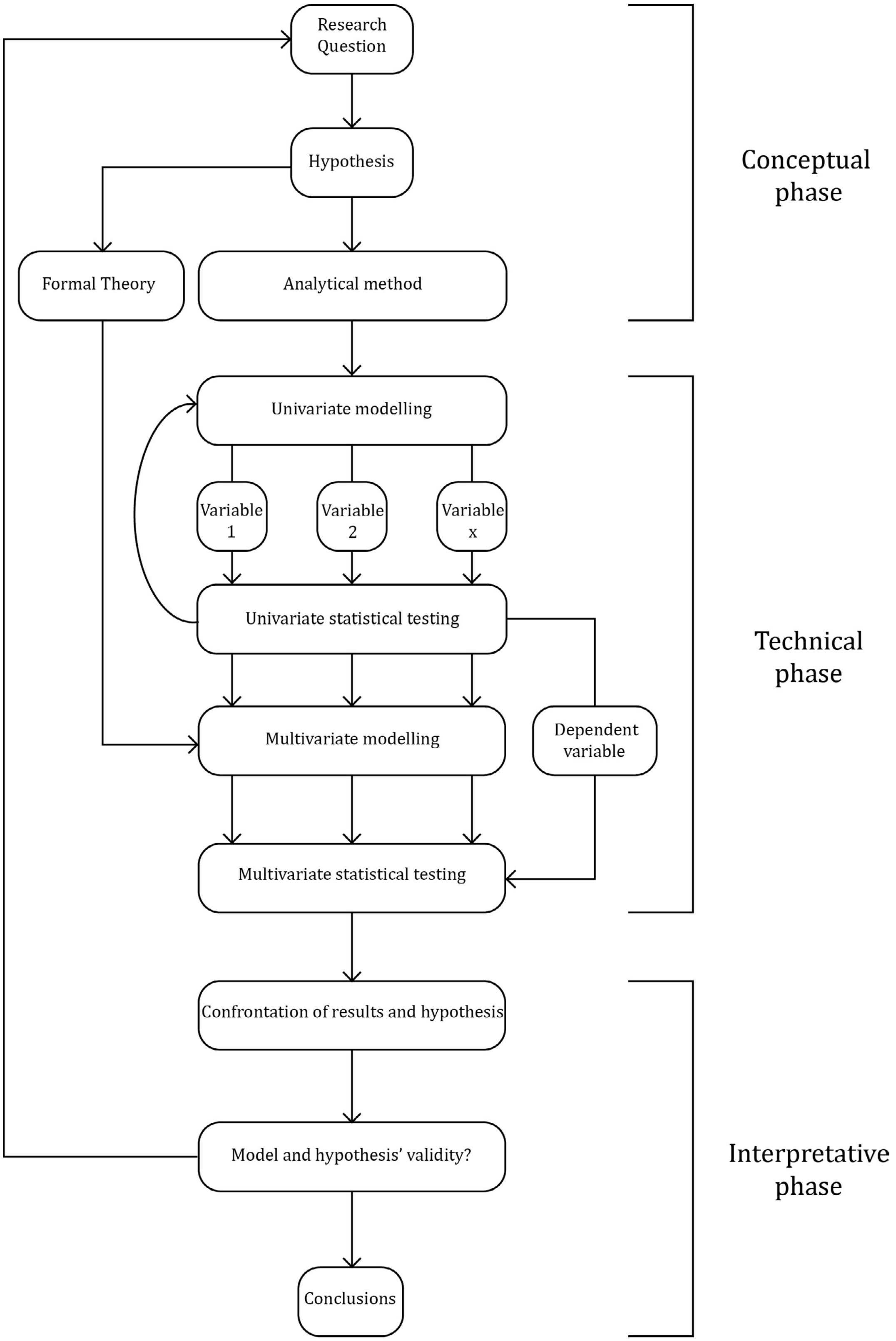

Figure 3. Diagram of the proposed theory-based modelling workflow.

Both univariate and multivariate models are then statistically confronted with the archaeological dataset. For this purpose, Chi-square tests are computed to evaluate the statistical randomness, as well as 'predictive values' for each class (Verhagen 2007, 48-49): Kvamme's gain, the relative gain, and the indicative gain. These values ultimately depend on the relative size of each predictive class area in the model and the frequency of sites present in each one. This paper only pursues the 'indicative value', as it relates to the accuracy of the model, by offering the ratio of actual sites to expected sites. It must therefore present a value higher than 1 if a class is expected to be predictive, much lower than 1 if the class is not, and in the vicinity of 1 if the class is expected to have no influence. This simple approach to modelling departs from other more complex and statistical works carried out recently. Indeed, the theory-based approach I chose for this study can not include such implementations, which I believe are better suited for producing predictive maps for cultural heritage management or for studies employing statistics in the model-building phase.

The interpretative phase of the framework compares the formal hypothesis with the statistical results. If the model's classification concurs with the statistical results, the hypothesis is validated; otherwise a new hypothesis must be formulated.

Models and results

The first aim of this study assesses the respective contributions of different environmental factors on site location. During this project it was possible to model some of the many factors that could influence site location: slope, topographical position (e.g. valley bottom, mid-slope, plateau, hilltop), accessibility of rivers, orientation of the landscape, and its annual solar radiation. In theory, the best agricultural conditions should influence site location, and one hypothesis is that rural settlements would preferably be located in the mid-lower slopes of valleys or the fertile plateaus, close to rivers and in areas facing south and southwest, therefore benefiting from the highest annual solar radiation.

The results of univariate models concerned with the physical environment showed that the orientation of the land and its annual solar radiation have no correlation with site location, contrary to the formal hypothesis (table 1). This may indicate that Roman farmers did not seek a higher solar exposure in the Somme, which may be due to its relatively gentle topography and dominant cereal production during the period. The statistical evaluation of the multivariate model of landforms, slopes and path distance to rivers nevertheless indicates that a moderate correlation can be derived in all regions except the fourth, where the landscape is very flat and homogeneous (fig.4). All areas of the landscape could be settled, with slight preferences for flat areas and mid-slopes which are close to rivers. Socio-economic variables may yield higher correlations.

To test this theory, it is hypothesised that Roman farmers chose locations from which they could easily access local markets, neighbouring cities and Roman roads, possibly with a good vantage point over the neighbouring land. Path distance models were created to evaluate these elements. Path modelling – also employed to model the accessibility of rivers – is a method used to map the cost (in hours) of movement through the landscape from a given point to another (point or segment), as well as movement across multiple or all locations in a given frame, depending on the slopes and the direction of movement (Herzog 2010; Güimil-Fariña et al. 2015;

Variable	Min	Medium	Max	Accuracy	Precision	Consistency	Validity
Slope	0.39	0.64	1.19	High	Medium	Medium	High
Aspect	0.82	1.10	1.00	Low	Low	Low	Low
Solar radiation	0.73	1.23	0.94	Low	Low	Low	Low
Deviation from mean elevation	0.38	0.74	1.25	High	Medium	Medium-high	High
Path distance to rivers	0.21	0.85	1.26	Medium	Medium	Medium	Medium
Multivariate: Landscape	0.46	0.65	1.41	High	High	Medium-high	High
Euclidian distance to roads	0.41	1.12	1.65	High	High	Medium-high	High
Path distance to main cities	0.25	0.94	1.26	High	Medium-high	Medium-high	High
Path distance to local markets	0.26	0.92	1.37	High	Medium-high	High	Very high
Prominence (openness)	1.17	0.97	0.84	Low	Low	Medium	Low
Multivariate: Landscape + socio-economic variables	0.11	1.02	1.52	Very high	High	Very high	Very high

Table 1. Synthesis of the evaluation of all models' performance. The minimal, average and maximal indicative values are given, as well as a summary of the accuracy, precision, consistency and validity, derived from the Kvamme's gain, relative gain, indicative values and Chi-square tests.

Lock et al. 2010; Verhagen and Jeneson 2012; Verhagen et al. 2014, Harris et al. 2006, 52–53). Vantage points could be computed as the visibility of a point in the landscape (viewshed analysis), or as the angle of vision from this point (openness analysis).

The results of univariate models of socio-economic factors indicate that vantage points did not play a significant role in site location, because visually secluded areas were settled in similar proportions as prominent ones. Nevertheless, the accessibility of neighbouring cities, markets, and roads are better correlated with site location, especially in a multivariate combination, including the preceding multivariate model of the landscape, improving its results in all classes (fig.5). Villas are only present in average or high expectation classes, but the other types

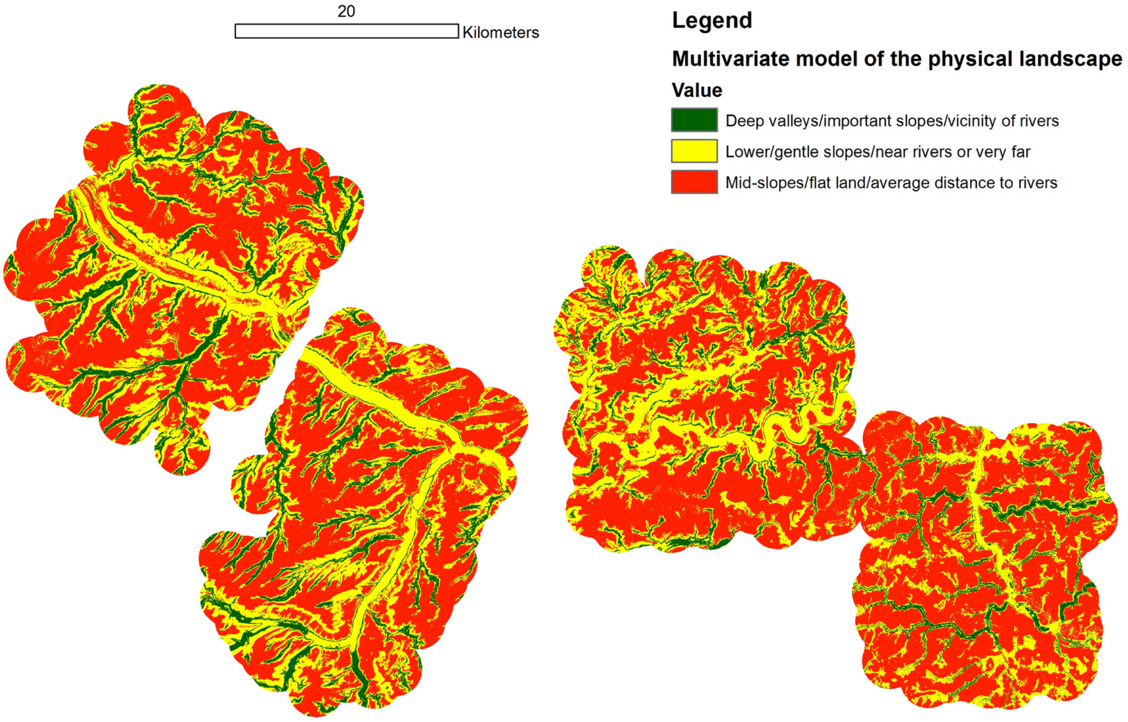

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Figure 4. Multivariate model of the variables related to the physical landscape. In red, areas of high site expectation, in yellow, medium expectation, and in green, low expectation.

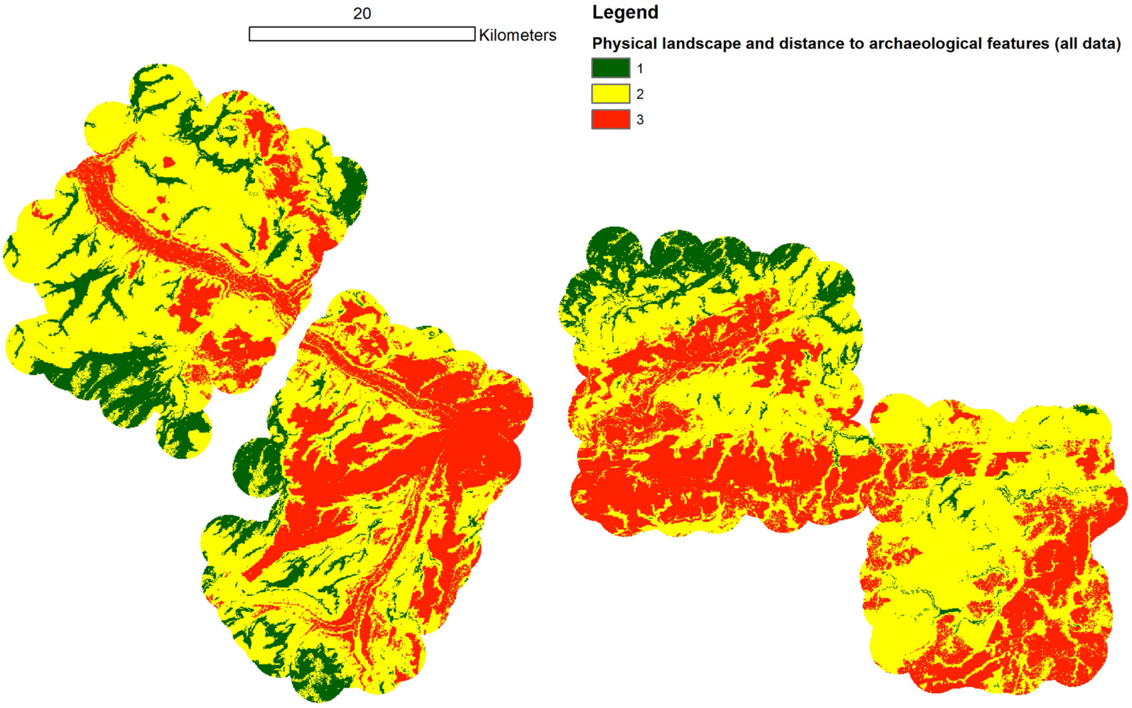

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Figure 5. Multivariate model of the socio-economic variables, merged with the physical landscape. In red, areas of high site expectation, in yellow, medium expectation, and in green, low expectation.

of rural settlements can sometimes be located in more secluded areas. Only the fourth micro-region yet again indicates a near homogeneity in its site location, as its interest points are well-distributed across the entire area and its physical landscape does not prevent movement. Overall, these variables display slightly larger intervals in their minimum and maximum indicative values, as well as a much better consistency than variables of the physical environment.

The results of all models – when concerned with specific settlement types – indicate that theories on post-built settlements being located in lesser quality and marginal areas do not hold (Blondiau 2014, 13), as they follow the same trends as stone-built settlements, providing the bulk of the statistical results. Furthermore, the large luxurious villas also follow the regional trends, without improvement on the predictive values of stone-built farms. Due to the severely diminished statistical relevance of dated settlements, only one notable interpretation can be extracted from the chronological influence on site location: in the Late Roman Period, rural settlements tend to survive better when located in areas of high accessibility regarding the main cities and the surviving local markets.

Discussion

The results of this study have a direct implication for the understanding of settlement patterns in the Roman Somme. Firstly, the rural settlement pattern displays a complete lack of determinism, be it in its relation to the physical landscape or to socio-economic features: all areas could be settled, albeit in varying frequencies, depending on the preceding parameters. If the gentle topography of the Somme may provide the main cause for this, it may also indicate that other parameters which were not modelled could produce higher correlations.

Many biases in the representation of settlements still prevent clear-cut interpretations of the models' results. For example, post-built settlements are very poorly known and represented, not only because they are less visible, but also because they erode more easily and only the most recent excavations uncovered a quantitatively significant corpus of sites (Duvette 2008; Blondiau 2014, 7-11; Agache 1976, 122-123).

If the locational patterns of post-built settlement showcased in this study were to hold against a more representative dataset, they may confirm recent theories on their positive economic development and integration (Ouzoulias 2009, 154; Blondiau 2014, 13). The most represented type of settlement – stone-built farms – display the same patterns, with a very high integration in the socio-economic network of the Roman province, just as much as the large villas, while at the same time being built extensively region-wide. This provides the picture of a countryside closely tied to urban markets, as surmised early on by Edith Wightman (1975, 623-624). This is valid even in the fourth century CE, when the massive abandonment of rural settlements does not upset prevailing locational patterns, supporting a certain continuity between the Early and the Late Roman Period (Van Ossel et al. 2000, 133; 2010, 4).

Finally and in a more methodological perspective, the approach developed in this study, in the continuation of recent attempts at integrating socio-economic elements in the modelling process, presents both advantages and disadvantages. Indeed, if it provides an explanatory and easily replicable framework, it can also provide lesser predictive values and much longer processing time: its classification is subjective, manually set and theory-driven, which was also the case with the Dutch

National Archaeological Predictive Model (Brandt et al. 1992, 271). Nevertheless, it allows for a certain ease and transparency in combining and evaluating very different types of variables, which do not always produce the same correlation with site location as in other study cases. For instance, solar radiation and the orientation of the land play larger roles in northeastern Gaul (Nüsslein 2016, 354-356).

Conclusion

The aim of this study was to uncover Roman rural site location preferences using a specifically designed explanatory methodology of predictive modelling, the first experiment of this type in northern Gaul. Using a large but heterogeneous dataset – partially improved through the definition of four micro-regions – it was possible to assert that the physical environment of the Somme, although relatively smooth and regionally very fertile, presents local variations sufficient to influence site location. Indeed, Roman farmers generally preferred building their farms in relatively flat areas or gently sloping valleys with easy access to the rivers, despite settling all areas. It was also possible to determine that socio-economic variables played a slightly more important role in site location, as the accessibility of market places was sought by all types of settlements, from post-built farms to large villas. In the East of the Somme, where the landscape is the flattest and every socio-economic centre is readily accessible, rural settlements display a very homogeneous site location pattern. The specifics of Roman agriculture and topography in the region should be responsible for the lack of influence of orientation and solar radiation, which certainly play a part in more rugged and Mediterranean provinces of the Empire. Future research in northern Gaul should aim to diversify the variables to be modelled, especially regarding palaeoenvironmental reconstructions of the landscape, its agricultural potential and social, economic, and cultural factors which have yet to be designed.

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