such research can make to measure what is transmitted in the sources, as the above cited archaeological studies demonstrate.

I cannot disagree with Rosenstein's last sentences, a great call to all the scholars involved in the study of the Roman army: 'War is too important a subject to be left to popularizers, whose knowledge too often is a generation or two out of date and whose ideas about how the Romans waged war do a disservice to the realities involved.' And 'to ignore the popular audience for Roman military history—or any other field of history for that matter—does a disservice both to the public and to our profession.' A magnificent colophon to a book which will help any type of Roman historian and archaeologist to better understand the intertwined formation of the Republic and the Roman institutions. However, hopefully these statements will be taken seriously by young scholars, not only by those who, like Rosenstein, enjoy a privileged vision of the Roman army studies after many years of devoted research.

References

Bellón, J.P., Gómez, F., Ruiz, A., Molinos, M., Sánchez, A., Gutiérrez, L. et al. 2009. Baecula: An Archaeological Analysis of the Location of a Battle of the Second Punic War. In: A. Morillo, N. Hanel & E. Martín, eds. *Limes XX* (Anejos de Gladius 13), pp. 17–29.

Fitzpatrick, A.P. & Haselgrove, C. eds. 2019. *Julius Caesar's Battle for Gaul: New Archaeological Perspectives*. Oxford: Oxbow Books.

García Sánchez, J., Gago Mariño, M., Costa-García, J.M., Fernández-Götz, M. 2019. El modelo Romanarmy.eu: patrimonio, comunicación e investigación en el pasado romano de Sasamón (Burgos). In: M. Rolo, M. ed., *Workshop Arqueologia 3.0. Comunicaçao, Divulgaçao e Socializaçao Da Arqueologia*. CHAIA Universidade de Évora- Fundação da Casa de Bragança, Vila Viçosa, Portugal. 15–16 March 2018. Bragança: Fundação da Casa de Bragança, pp. 101–119.

Jiménez, A., Bermejo, J., Valdés, P., Moreno, F. & Tardio, K. 2020. Renewed Work at the Roman Camps at Renieblas near Numantia (2nd-1st c. BC). *Journal of Roman Archaeology*, 33: 4–35. https://doi.org/10.1017/S1047759420000896.

Menéndez, A., García-Sánchez, J., Costa-García, J.M., Fonte, J., González-Álvarez, D. & Vicente, V. 2020. Following the Roman Army between the Southern Foothills of the Cantabrian Mountains and the Northern Plains of Castile and León (North of Spain): Archaeological Applications of Remote Sensing and Geospatial Tools. *Geosciences*, 10(12): 485. https://doi.org/10.3390/geosciences10120485.

Momigilano, A. 1975. *Alien Wisdom: The Limits of Hellenization*. Cambridge: Cambridge University Press.

Stek, T.D. & Pelgrom, J. 2014. *Roman Republican Colonization: New Perspectives from Archaeology and Ancient History*. Rome: Palombi.

Terrenato, N. 2019. *The Early Roman Expansion into Italy*. Cambridge: Cambridge University Press.

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Mark Gillings, Piraye Hacıgüzeller and Gary Lock, eds. *Archaeological Spatial Analysis: A Methodological Guide* (London & New York: Routledge, 2020, 512pp., 64 colour & 188 b/w illustr., hbk, ISBN 978-0-815-37323-0)

Human actions and, hence, material remains of human actions are rooted in space. It therefore comes as no surprise that archaeology shows such a deep interest for spatial patterns, spatial relationships, and spatiality. Spatial thinking has a

long history in the archaeological discipline, starting with early distribution maps and site plans, reductionist models of cultural diffusion, and simplistic investigations of ecological and social relationships. Archaeological spatial analyses were formalized in the 1960–1970s, with the development of locational modelling techniques based on quantitative methods and, as a result, supposed objectivity (e.g. Hodder & Orton, 1976). As criticisms were raised against processualism and positivism in the 1980s, the focus shifted to the subjective, human and meaning-laden character of space, place, and landscape. The rising popularity of spatial technologies and especially Geographical Information Systems (GIS) during the 1990s was thus met with distrust by proponents of post-processualist approaches, who rejected what was perceived as a return to a Cartesian, dehumanized, and environmentally deterministic understanding of past landscapes (e.g. Thomas, 2004). Yet, over the past two decades, practitioners of spatial analysis in archaeology have shown an increasing enthusiasm to engage not only in methodological but also in theoretical developments (e.g. Bevan & Lake, 2013; Howey & Brouwer Burg, 2017; Gillings et al., 2019). *Archaeological Spatial Analysis: A Methodological Guide* continues this trend. Edited by three leading researchers in geospatial technologies and digital archaeology, it is devoted to formal techniques of spatial analysis and their application in archaeology. Digital technologies hold a central role in the book, as they do in contemporary archaeological spatial analysis, without being its main focus. Lengthy discussions on computational issues and software solutions are therefore avoided; instead, the book intends to serve as a guide for archaeologists to 'choosing the appropriate technique, applying it correctly, and understanding its implications both theoretically and practically' (p. i).

Archaeological Spatial Analysis comprises an introduction by the editors (Ch. 1) and twenty-three chapters by invited specialists (Chs 2–24). Each chapter focuses on either a key technique or a particular issue pertaining to the analysis of spatial data. The techniques discussed in the book emerged first in various other disciplines (e.g. geography, architecture, sociology, etc.), but the focus here is strictly on their application, potential, and limitations for the study of archaeological evidence. *Archaeological Spatial Analysis* is richly illustrated with 188 in-text black and white figures, sixty-four of which are reproduced as colour figures grouped into two batches.

In their introductory chapter (Ch. 1), Gillings, Hacıgüzeller, and Lock set the stage, by discussing the centrality of space in archaeological practice and reviewing the developments of archaeological spatial analysis between the sixteenth and the twenty-first centuries. They advocate for analyses that are grounded in effective spatial thinking, informed by theory, applied critically, and used within an exploratory and interpretative process. Chapters 2 and 3 go on to address crucial issues that rarely receive the attention they deserve in the archaeological literature: the preparation of data for spatial analysis, curation, and reuse (Ch. 2, by Gupta); and sampling strategies (Ch. 3, by Banning). Gupta's chapter is of particular relevance in the Digital Age and, indeed, the Age of Big Data: digital technologies produce exponentially increasing amounts of information that run the risk of becoming obsolete without relevant metadata. Every step of data acquisition, processing, transformation, analysis, and interpretation must be documented systematically if archaeologists are to ensure that their methods and results can be replicated and their datasets reused. As a step towards this goal, Gupta demonstrates the potential of scripted workflows, version control

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for data management, Open Science, and collaborative research.

Chapters 4 and 5 explore point pattern analysis (by Bevan) and percolation analysis (by Maddison)—i.e. mathematical techniques to identify patterns and clusters in the spatial arrangement of points which, in archaeology, represent entities such as sites, buildings, and artefacts. Lloyd and Atkinson (Ch. 6) then discuss geostatistics, which offers different possibilities for characterising the spatial structure of archaeological variables and for predicting the value of these variables at locations where no samples are available. Spatial interpolation is the focus of Chapter 7, in which Conolly examines three statistical methods (i.e. distance weighting interpolation, thin plate spline interpolation, and kriging) to estimate the distribution of values (e.g. artefact densities, elevation above sea level) across a continuous surface, based on sample points. This chapter is particularly effective in illustrating the extent to which the outcome varies according to the method and parameters of interpolation. In this way, Conolly emphasizes the need for spatial analysts to make informed decisions based on the available data, computational and statistical issues, and archaeological research questions.

Hacıgüzeller (Ch. 8) discusses the use of correlation and linear regression analysis to investigate the relationships that may exist between variables of interest. The following chapters introduce techniques that account for two peculiar characteristics of archaeological spatial data: (1) it results from processes that may be heterogeneous across space and may therefore require the application of local (rather than global) statistics (Ch. 9, by Crema); and (2) it suffers from unknown degrees of uncertainty, imprecision, vagueness, and incompleteness, which can be taken into consideration through fuzzy logic and fuzzy set theory (Ch. 10, by Fusco & de Runz). Chapter 11, by Pouncett, is concerned with the use of Bayesian statistics and the calculation of residuals to interpret the results of strontium and oxygen isotope analyses and, in this way, track mobility and migration in the archaeological record. Kvamme (Ch. 12) then returns to point patterns (see also Ch. 5), focusing on their first-order characteristics. The author presents statistical methods to test hypotheses regarding preferences for settlement location in relation to characteristics of the natural and social environment. Site location preferences are also the subject of Verhagen and Whitley's chapter (Ch. 13) on predictive modelling. Used in cultural resource management and in archaeological research, predictive models assess the probability that archaeological sites will occur at specific locations across the landscape, based either on statistical extrapolation from observed patterns or on theoretical assumptions regarding human behaviour. Verhagen and Whitley discuss the potential and limitations of this controversial technique of spatial modelling, while emphasizing that the result depends strictly upon the data and theories employed to create the model.

In Chapter 14, Lake presents the computationally complex technique of agent-based modelling (ABM) in an intelligible manner. ABM simulates how the combined actions of individual agents result in large-scale and long-term processes of change, thus offering new opportunities to investigate archaeological patterns, test existing theories, and explore alternative hypotheses.

The next four chapters deal with different aspects of connectivity and interaction. Brughmans and Peeples (Ch. 15) discuss the analysis of spatial networks among settlements, while Thaler (Ch. 16) reviews space syntax, which archaeologists employ to explore the accessibility of settlements and buildings, the structure of which is

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simplified as topological networks for the purpose of the analysis. Visibility and movement patterns—which can also be investigated in the form of networks—are extremely popular topics in archaeological spatial analyses, notably because they place issues of human perception and experience back at the centre of digital modelling. Gillings and Wheatley (Ch. 17) take a critical approach to GIS-based analysis of visibility, while Herzog (Ch. 18) thoroughly describes the steps involved in the calculation of cost surfaces, site catchments, and least-cost paths. She meticulously compares the results obtained using different cost functions and algorithms, thus demonstrating how crucial it is for archaeologists to make informed decisions and adopt a critical stance when performing spatial analyses.

Remote sensing is the subject of two chapters concerned, respectively, with the use of satellite imagery to study archaeological landscapes (Ch. 19, by Kalaycı) and the application of geophysical techniques to map buried archaeological sites (Ch. 20, by Sarris).

The book concludes with four chapters that address current and future challenges in archaeological spatial analysis. Taylor (Ch. 21) tackles the role played by time and temporality in spatial modelling. In particular, he underlines the limits of available technologies and methodologies, which conceive of time as an attribute of spatial features instead of aiming for a full integration of time and space. Green (Ch. 22) then investigates methods to approach archaeological 'Big Data'—i.e. datasets that are too large and complex to be assembled and analysed without automated methods. In Chapter 23, Dell'Unto explores 3D applications in archaeology. Considering the breadth of such applications, he focuses on the use of 3D realistic models to support archaeological field practice, spatial analysis, and archaeological interpretation. Finally, a stimulating chapter by Eve and Graham (Ch. 24) argues for the adoption of multi-sensory methods to investigate, experience, and represent spatial patterns. They explore the sonification of data—that is, its representation based on the sense of hearing rather than sight—and demonstrate how such methods offer innovative means to engage archaeologists and the public with the past.

Archaeological Spatial Analysis is a dense volume, extremely rich in information and remarkable for the high standard of each one of its contributions. There is no doubt that significant efforts have been made to ensure intelligibility, but some parts of the book are inevitably more accessible to non-experts than others. The chapters on agent-based modelling, spatial network analyses, and space syntax, for instance, provide entry-level introductions to these techniques. In contrast, others require previous experience with statistics and GIS, and are best read alongside manuals such as those by Wheatley and Gillings (2002) and Conolly and Lake (2006), which remain valuable references on this matter.

The book reflects the diversity that nowadays characterizes techniques and methods of spatial analysis in archaeology. It is disappointing, however, that it does not reflect the (finally) growing diversity among spatial analysts in archaeology and, for that matter, among archaeologists. In particular, only four out of the thirty contributors to the book are women.

In terms of content, one could perhaps regret the lack of transparency regarding the decision to address some techniques (e.g. satellite and geophysical remote sensing) over others (e.g. LiDAR, aerial photography). One could also regret the sometimes unclear rationale behind the order in which the chapters succeed one another, which is somewhat detrimental to the unity of the book as a whole. Nevertheless, *Archaeological Spatial Analysis*

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achieves coherence thanks to the systematic structure of most chapters. Per the editors' request, the authors usually start by introducing the particular technique and reviewing its history of use in archaeology, before presenting the methodology, illustrating its application using one or more archaeological case studies, and concluding by discussing prospects and perspectives.

One of the greatest strengths of *Archaeological Spatial Analysis* is that it tackles the risks associated with the routinization of spatial technologies in archaeology. Over the past two decades, such technologies have evolved from highly specialized subfields (employed only by trained experts) to relatively common tools. According to a recent survey, geospatial applications nowadays account for more than ten per cent of the archaeological literature (McCoy, 2021: 4). The popularity of these applications has multiple causes such as the establishment of specialized academic programs, technical advances, the democratization of hardware and the availability of open-source software, as well as the development of off-the-shelf tools that make it possible to complete complex spatial and statistical analyses in a couple of clicks. The latter has a serious downside: it may give the impression that basic training suffices to input data into a computer, produce an output and, in this way, become a spatial analyst. However, it is one thing to produce an output, another to produce a meaningful output, and yet another to produce a meaningful output that archaeologists are capable of interpreting in a critical and informed manner. Accordingly, *Archaeological Spatial Analysis* addresses methodological and theoretical concerns, discusses the algorithms and parameters at play, and contributes to debugging black boxes. Choices in terms of techniques, options, samplings, search radii, etc. are explained, and the consequences of taking specific decisions are made explicit. In this way, the editors have certainly achieved their goal of providing a methodological tool to 'make archaeologists better spatial thinkers, and as a result better spatial analysts' (p. 13).

References

Bevan, A. & Lake, M., eds. 2013. *Computational Approaches to Archaeological Spaces*. London & New York: Routledge.

Conolly, J. & Lake, M. 2006. *Geographical Information Systems in Archaeology* (Cambridge Manuals in Archaeology). New York: Cambridge University Press.

Gillings, M., Hacıgüzeller, P., & Lock, G., eds. 2019. *Re-Mapping Archaeology: Critical Perspectives, Alternative Mappings*. London & New York: Routledge.

Hodder, I. & Orton, C. 1976. *Spatial Analysis in Archaeology* (New Studies in Archaeology 1). New York & London: Cambridge University Press.

Howey, M.C.L. & Brouwer Burg, M., eds. 2017. Archaeological GIS Today: Persistent Challenges, Pushing Old Boundaries, and Exploring New Horizons. *Journal of Archaeological Science*, 84: 1–136.

McCoy, M.D. 2021. Defining the Geospatial Revolution in Archaeology. *Journal of Archaeological Science: Reports*, 37. doi: https://doi.org/10.1016/j.jasrep.2021.102988

Thomas, J., 2004. *Archaeology and Modernity*. London: Routledge.

Wheatley, D. & Gillings, M. 2002. *Spatial Technology and Archaeology: The Archaeological Applications of GIS*. New York & London: Taylor & Francis.

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