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2nd c. CE defenses around small towns in Roman Britain structured by road network connectivity

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Abstract: The large-scale provision of defenses around small towns in Roman Britain during the 2nd c. CE is without parallel in the Roman Empire. Although the relationship between defended small towns and the Roman road network has been noted previously, provincial-level patterns remain to be explored. Using network analysis and spatial inference methods, this paper shows that defended small towns in the 2nd c. are on average better integrated within the road network – and located on road segments important for controlling the flow of information – than small towns at random. This research suggests that the fortification of small towns in the 2nd c. was structured by the connectivity of the Roman road network and associated with the functioning of the *cursus publicus*.

Keywords: Network analysis, Roman Britain, small towns, hypothesis testing, connectivity, road network

The provision of defenses around towns in Roman Britain has attracted interest since the 1930s,[1] with a well-established general outline. in the 1st c. CE, the provision of defenses was limited to a few public towns (*coloniae, municipia, civitas* capitals).[2] In the 2nd c. CE, a large number of earthwork defenses were erected in public towns, as well as in settlements subordinate to *civitas* capitals in political and administrative status (henceforth, small towns).[3] In the 3rd c. CE, more small towns received walls, and finally, in the 4th c. CE, external towers were added to existing walls.[4]

Although it should be noted that the issue of defining a "small town" continues to be debated,[5] with the selection and subdivision commonly based on characteristics such as function or origin,[6] small towns differ from *civitas* capitals in several ways: they often lacked official administrative status, planned rectangular street grids, and key public facilities such as a forum and bathhouses.[7] Although the presence of small towns is common to all provinces of the Roman Empire,[8] the large-scale provision of defenses around small towns in Roman Britain – whether during or after the 2nd c. – is without parallel.[9] Fortification of small towns in neighboring provinces such as Gaul, Germany, and Raetia remained rare, with defenses often limited to settlements with *civitas* status.[10]

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1 Hobley 1983, 78.
2 Frere 1984b.
3 Burnham and Wacher 1990; Wacher 1975.
4 Frere 1984a.
5 Booth 1998; Rust 2006; Todd 1970.
6 E.g., Burnham 1986; Burnham and Wacher 1990.
7 Millett 1990, 144–45; Todd 1970; Wacher 1975.
8 De Ligt and Bintliff 2020 for an overview.
9 Esmond-Cleary 2003.
10 Esmond-Cleary 2007.

Due to this, Esmond-Cleary suggests that small towns from the 2nd c. onward played a more significant role within the *civitates* and Roman Britain more generally compared to other provinces.[11]

Traditionally, the motivation to construct defenses around towns has been driven by two hypotheses: (1) a centralized government response to an actual or perceived threat,[12] or (2) a symbol of civic pride initiated by local authorities.[13] Although civic pride and display is considered a plausible explanation for defenses around higher-status towns (*coloniae, municipia, civitas* capitals),[14] the significant number of small towns defended in the 2nd c. remains more difficult to explain.[15] For example, the defense of small towns has been related to specific periods of historical upheaval,[16] such as the usurpation of Clodius Albinus (r. 193–197 CE). However, the use of "external threat" as the explanatory model has become less tenable because defenses show chronological phasing, as well as the more general issue of fitting archaeological evidence into historical narratives.[17] Furthermore, although the motivation of civic pride has been used as an explanation for the provision of defenses around small towns,[18] Esmond-Cleary notes that this is "no more than a possibility and does little to explain the fortification of the 'small towns.'"[19]

In contrast, the defense of small towns has been linked to important installations, such as the *mansiones* and *mutationes* that were integral for the development and functioning of the Roman provincial transportation system (*cursus publicus*).[20] Through the *cursus publicus*, government communication was made possible – which was essential for securing and maintaining control throughout the empire.[21] Nonetheless, this led Smith and Fulford to ask: "if the common factor linking defended settlements on the major roads was that they supported the *cursus publicus* […], why were not all such settlements provided with defences?"[22] With this question in mind, this research will use network analysis and spatial inference methods to identify provincial-level patterns in the relationship between small towns fortified in the 2nd c. and the connectivity of the Roman road network.

Specifically, two testable hypotheses will be investigated:

(1) Defended small towns were well integrated within the road network for the efficient transfer of information.

(2) Defended small towns were located on roads that were important for controlling the flow of information across the road network.

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11 Esmond-Cleary 2003.

12 Frere 1984a; Wacher 1975, 75.

13 Millett 1990, 139–40.

14 Esmond-Cleary 2007.

15 Esmond-Cleary 2003; Esmond-Cleary 2007.

16 E.g., Frere 1991, 241; Wacher 1962.

17 Esmond-Cleary 2007.

18 Millett 1990, 137–40.

19 Esmond-Cleary 2007.

20 Black 1995; Burnham and Wacher 1990, 12–14; Esmond-Cleary 2007; Smith and Fulford 2019.

21 Kolb 2001; Haynes 2002.

22 Smith and Fulford 2019, 18.

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Materials and methods

The data and code are available at https://github.com/josephlewis/Defended_Small_Towns.

Roman road network

The Roman road network was downloaded from Bishop.[23] Based on Roman roads identified by Ivan Margary,[24] this dataset represents the most comprehensive Roman Britain road network currently available. It should be noted, however, that knowledge of the Roman road network is currently incomplete,[25] with the region north of London showing a greater concentration of roads.[26] Although this reflects local interest in identifying Roman roads[27] rather than the true distribution of Roman roads in Roman Britain, the impact of this on the analysis is outside the scope of this paper and will therefore not be further explored.

To ensure that the Roman road network as currently understood was interconnected, and thus sufficient for network analysis, small gaps were manually fixed by connecting road ends via straight lines (Fig. 1a). The choice to manually join roads – predominately to urban centers – over other automated methods such as connecting all road ends within 500 m[28] or least-cost path analysis[29] aimed to minimize the introduction of additional uncertainty.[30] The road network was converted to a network graph, with road vertices acting as nodes and road segments as edges (Fig. 1a).

Small towns

Data on 90 small towns with sufficient information on the date of defenses was collated from Millett,[31] using Smith and Fulford for more accurate chronologies when possible.[32] Four small towns (Brough-on-Fosse, Dorn, Dropshot, and Sandy Lane) were removed from the analysis due to uncertainty in the dates of fortification.[33] Nonetheless, the large number of small towns included within the analysis aims to sufficiently represent small towns as a category. The 90 small towns were filtered to those within 1 km from the Roman road network, ensuring that the small towns were deemed to be sufficiently integrated within it. The remaining 79 small towns were used within the analysis, with 22 (28%) defended in the 2nd c. The small towns were subsequently attached to the Roman road-network graph to become nodes (Fig. 2).

23 Bishop 2014.
24 Margary 1973, 170.
25 Estimated to be 40% at best by the Roman Roads Research Association 2021.
26 Margary 1973.
27 E.g., The Viatores 1964.
28 E.g., Brookes and Huynh 2018.
29 E.g., Orengo and Livarda 2016.
30 E.g., Lewis 2021.
31 Millett 1990, 154–56.
32 Smith and Fulford 2019.
33 Smith and Fulford 2019.

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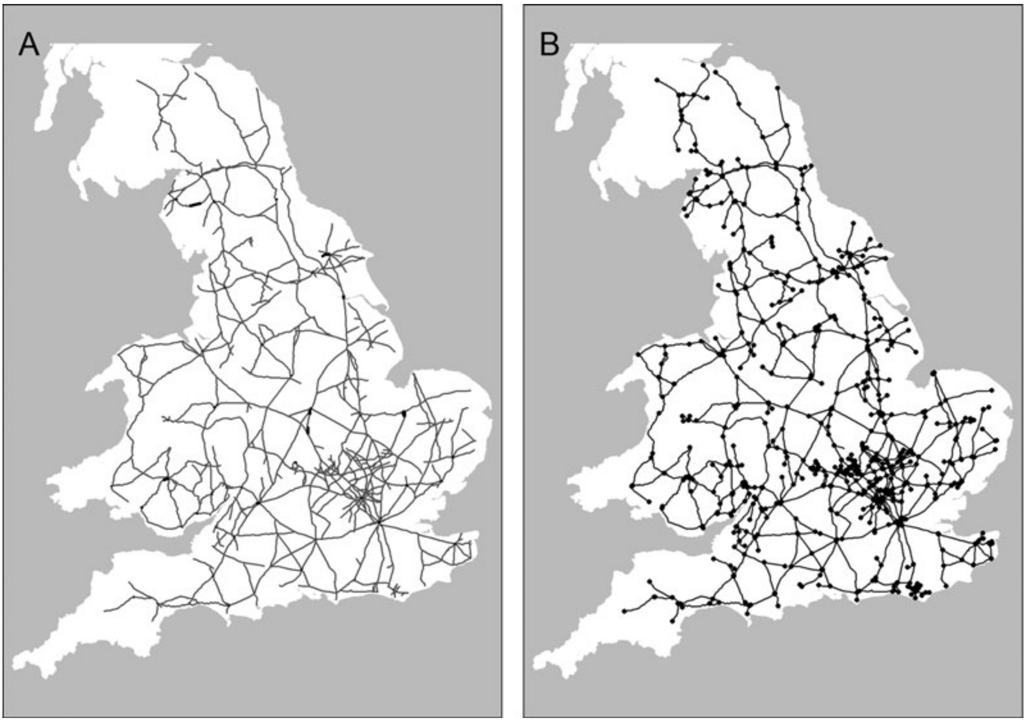

Fig. 1. *(a) Roman roads in Roman Britain using Bishop (2014) (grey), with small gaps filled by present author (black) and (b) network graph representation of the Roman road network with vertices acting as nodes and road segments as edges.*

Network analysis and spatial inference

The application of network analysis to archaeological research has rapidly increased.[34] By representing data as a network graph – with nodes signifying points, and edges representing the connections between them – the fundamental characteristics of a network structure at a node and network level can be analytically described.[35] For example, Pau de Soto assessed the accessibility of the Iberian Peninsula using the Roman road network,[36] Orengo and Livarda analyzed the circulation of goods in relation to Roman Britain road network properties,[37] and Brookes and Huynh assessed the correlation in town PageRank values to their status in Roman and early medieval England.[38]

Although less common in archaeology, the network representation of archaeological data can also be used in the formal testing of hypotheses.[39] More specifically, the significance of a spatial pattern – in this case, whether defended small towns were well integrated within the road network and located on Roman roads important for controlling the flow of information – can be quantified by randomly reshuffling the characteristic of interest while

34 Brughmans and Peeples 2017.

35 Brughmans 2010; Gorenflo and Bell 1991; Verhagen, Nuninger, and Groenhuijzen 2019.

36 de Soto 2019.

37 Orengo and Livarda 2016.

38 Brookes and Huynh 2018.

39 Östborn and Gerding 2014.

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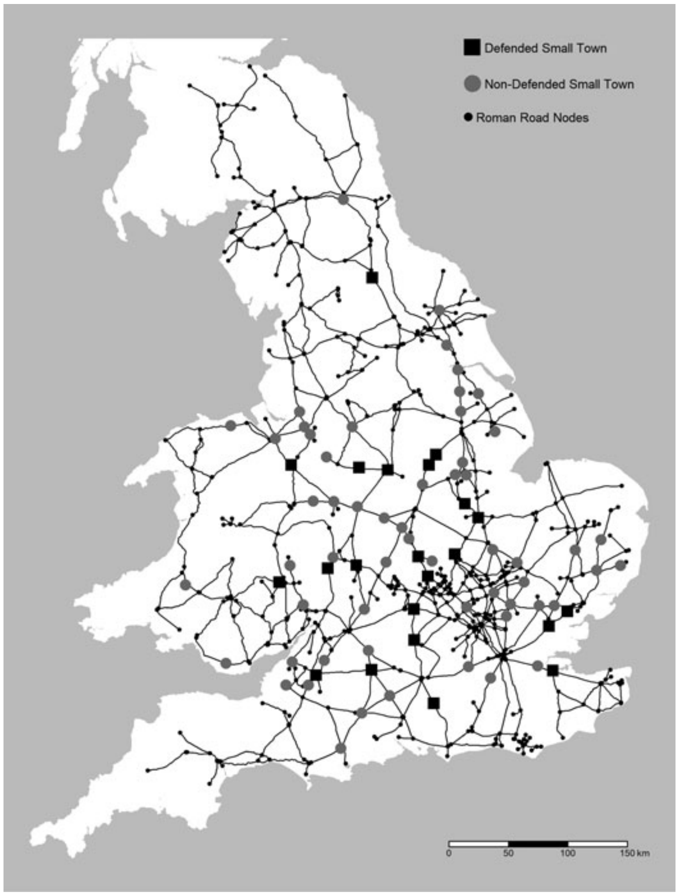

Fig. 2. *Roman roads with 2nd-c. defended and nondefended small towns as nodes. (Map by J. Lewis.)*

keeping all other aspects of the data not relevant to the hypothesis constant.[40] Through this, the underlying process of interest and whether it resulted in the spatial pattern can be evaluated. More simply put, how likely is it that the observed spatial pattern of defended small towns has arisen from a random process given the underlying spatial distribution of small towns?[41]

Network analysis measures

NODAL EFFICIENCY—The efficiency of defended small towns for communication was measured via nodal efficiency, which is the inverse of the average length of the minimum path length between a given node and all other nodes in the network (Fig. 3).[42] Nodes with high nodal efficiency are well integrated within the overall network and indicate a higher capability of transferring information efficiently to all other nodes.[43] The nodal efficiency of all small towns was calculated, with the nodal efficiency of defended small towns mean averaged.

40 Good 2005.

41 Modified from Fotheringham and Brunsdon 2004.

42 Latora and Marchiori 2001.

43 Latora and Marchiori 2001; Latora and Marchiori 2003.

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EDGE BETWEENNESS—The importance of a road segment for controlling the flow of traffic was measured via edge betweenness, which is the number of shortest paths in the graph that pass through a given edge.[44] Edges with high edge betweenness therefore control the flow of information and act as "bridges" between multiple parts of the network[45] (Fig. 4). The edge betweenness of all road segments was calculated, with the edge betweenness of roads with defended small towns situated along them mean averaged.

CREATING THE NULL HYPOTHESIS—The null hypothesis of mean nodal efficiency and mean edge betweenness was calculated by randomizing the status of small towns – that is, randomly relabeling whether a small town was "defended" or "nondefended" (Fig. 5). The randomization in the status of the small towns reflects that of a random process,[46] with the rejection of the null hypothesis signifying that the observed pattern of defended small towns is unlikely to have occurred by chance. A one-sided Monte Carlo hypothesis test was used to statistically compare the mean nodal efficiency and mean edge betweenness of the observed pattern of defended small towns against 999 simulations where the "defended" or "nondefended" status of small towns was randomized ($p < 0.05$). Although a relatively small number of simulations are required when using Monte Carlo hypothesis testing, with 99 simulations often sufficient,[47] 999 simulations results in a better estimate of the p-value.[48] Under a Monte Carlo hypothesis test procedure,[49] N values of the test statistic (e.g., mean nodal efficiency) from simulations under the null hypothesis (where status is randomized) are compared to the observed statistic (where status is not randomized), with the p-value obtained by counting the number m of simulated test statistics at least as extreme as the observed test statistic ($p\text{-value} = [m + 1] / [N + 1]$).[50]

Results

Network measures of defended small towns

The mean nodal efficiency of the defended small towns is greater than nondefended small towns, with the defended small towns showing less variance in nodal efficiency values (Fig. 6a). Furthermore, the mean edge betweenness of road segments with defended small towns is greater than road segments with nondefended small towns (Fig. 6b).

Using the Monte Carlo hypothesis test procedure, the mean nodal efficiency of the 22 defended small towns is statistically significant ($p < 0.05$) compared to the 999 randomized simulations (Fig. 7a). This means that the defended small towns on average possess a higher capability of transferring information to other nodes and are therefore more integrated within the road network than small towns chosen at random. Similarly, the mean edge betweenness of road segments with defended small towns is statistically significant ($p < 0.05$) compared to the randomized simulations (Fig. 7b), showing that defended

44 Freeman 1978.

45 Freeman 1978.

46 Fotheringham and Brunsdon 2004; Östborn and Gerding 2014.

47 Besag and Diggle 1977; Hope 1968.

48 Gentle 2002, 55–57.

49 Barnard 1963.

50 North, Curtis, and Sham 2002; Turner and Jeffs 2017.

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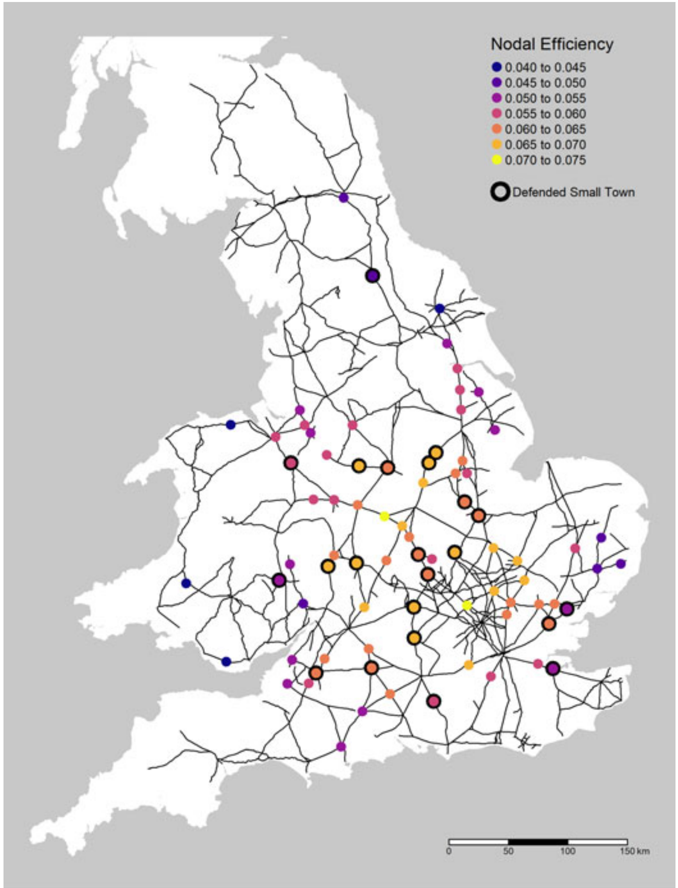

Fig. 3. *Nodal efficiency of defended (black border) and nondefended small towns (no border). (Map by J. Lewis.)*

small towns were on average located on roads that had more control over the flow of information while also acting as bridges to other parts of the Roman province.

Discussion and conclusion

Although the relationship between defended small towns and the Roman road network has been noted previously,[51] this research has shown that the connectivity of the Roman road network is associated with the fortification of small towns in the 2nd c. CE. Defended small towns in the 2nd c. on average not only possessed higher nodal efficiency but were located on roads with higher values of edge betweenness than nondefended small towns. Furthermore, the rejection of the null hypotheses shows that the small towns defended in the 2nd c. were on average better integrated within the road network than small towns at random, and they were situated along road segments that were important for controlling the flow of information across the road network. Although the reason for fortifying small towns was complex and likely not due to a single cause,[52] the provincial-level pattern of defended small towns in the 2nd c. having high connectivity while also being well integrated

[51] e.g. Burnham and Wacher 1990, 235–78

[52] Esmond-Cleary 2003, 84

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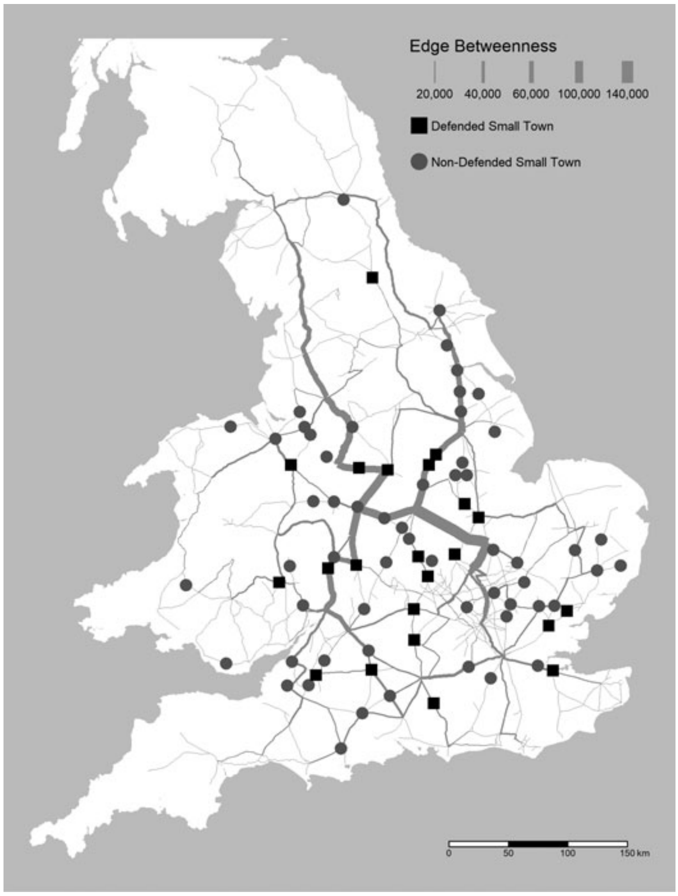

Fig. 4. *Edge betweenness of each road segment in the road network with defended small towns. (Map by J. Lewis.)*

within the road network echoes the fundamental role defended small towns played in the communication of information via the *cursus publicus*.[53] This suggests that, as noted by Millett,[54] although civic competition between communities might have driven the provision of defenses, government officials were keen to ensure that the defenses also protected administrative infrastructure related to the functioning of the *cursus publicus*.

Nevertheless, it is important to be aware of limitations. First, the nodal efficiency and edge betweenness are based on the edges present within the road network. Although the impact of missing road segments – as well as filling in gaps using straight lines – is assumed to be minimal, it highlights the need for a more complete understanding of the road network in Roman Britain.[55] Second, this analysis ignores the possibility of maritime and river navigation, resulting in potentially undervaluing the nodal efficiency and edge betweenness for small towns and road segments near rivers and the coast. Although this effect is assumed to be small due to the majority of defended small towns being in

53 Black 1995; Smith and Fulford 2019.

54 Millett 1990, 140.

55 E.g., Roman Roads Research Association 2021

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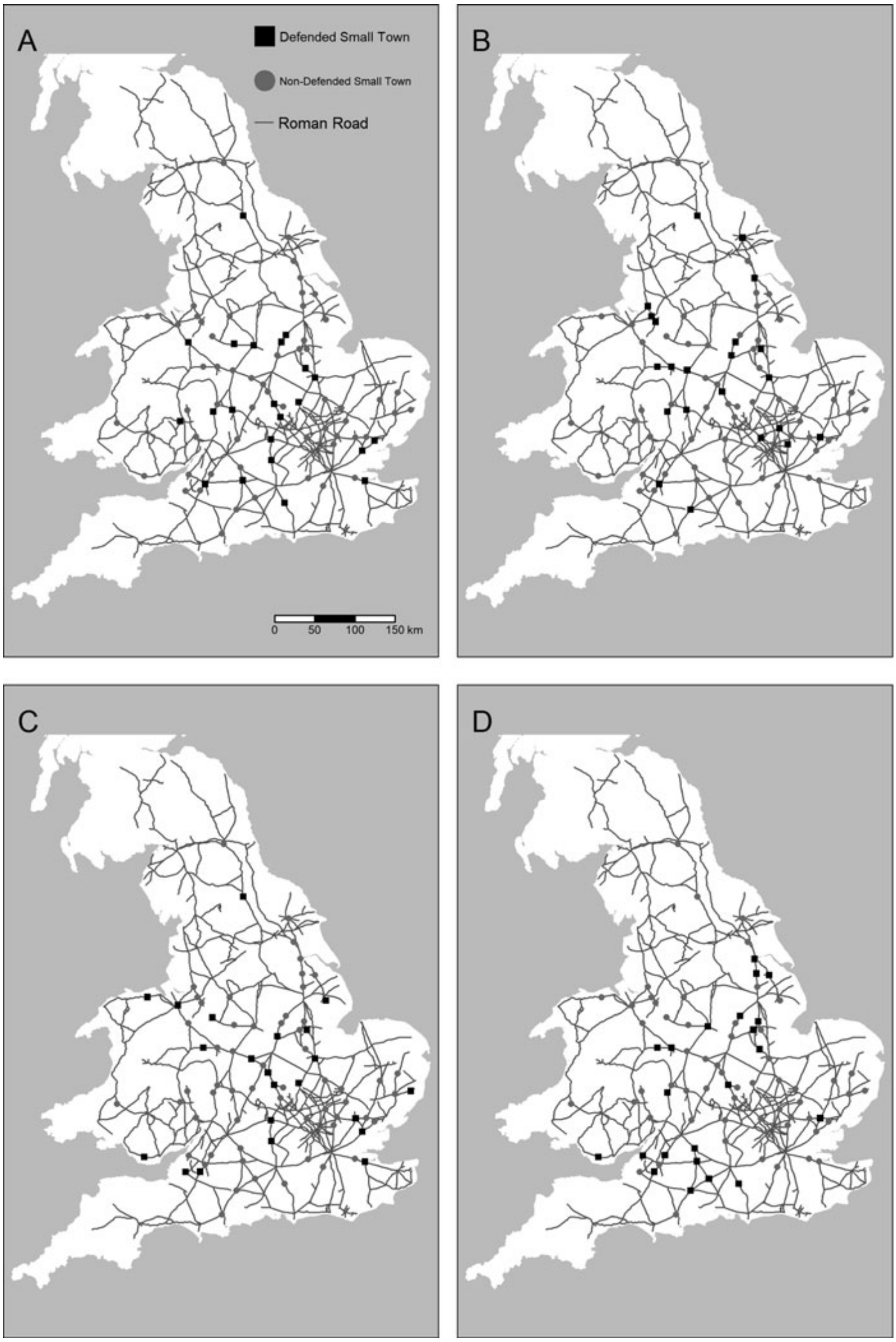

Fig. 5. *Roman road network with observed distribution of small towns (a) and examples after randomly shuffling the "defended" status of small towns (b, c, and d). (Maps by J. Lewis.)*

the central belt of Roman Britain, future research is needed to incorporate multiple types of transportation when conducting provincial-level analyses.[56] Last, given that the present analysis focused exclusively on small towns defended in the 2nd c., there is a need to

56 E.g., Carreras and de Soto 2013; Carreras, de Soto, and Muñoz 2019

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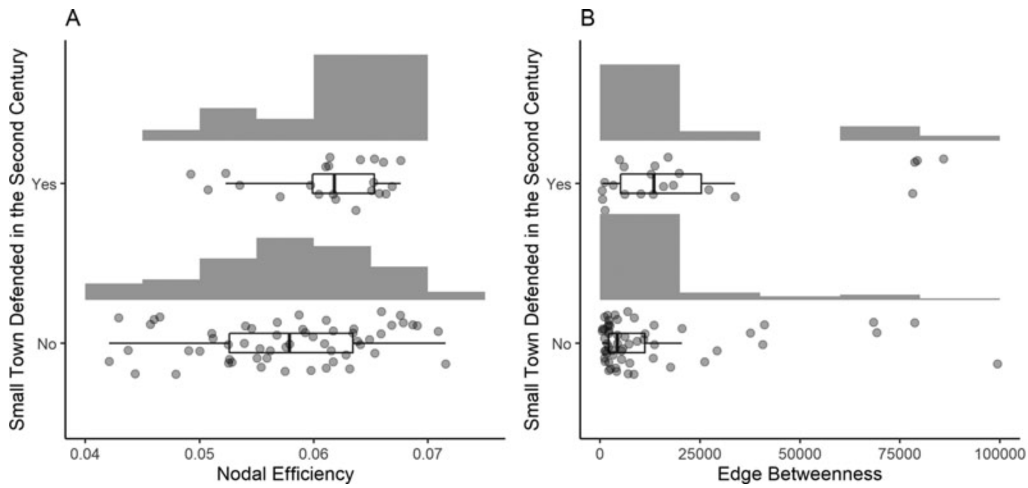

Fig. 6. *(a) Nodal efficiency of defended and nondefended small towns and (b) edge betweenness of defended and nondefended small towns.*

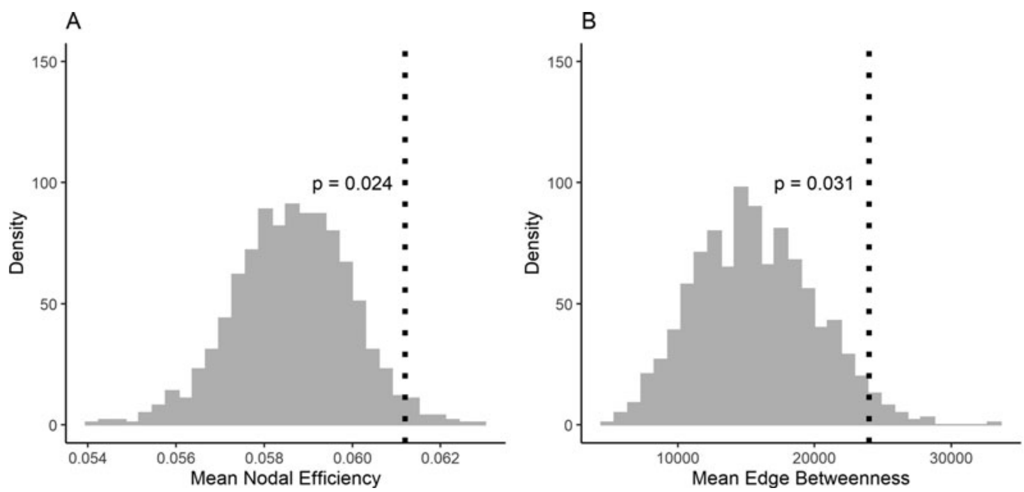

Fig. 7. *(a) Distribution of mean nodal efficiency from randomized simulations and the true mean nodal efficiency of defended small towns (black dashed line) and (b) distribution of mean edge betweenness from randomized simulations and true mean edge betweenness of defended small towns (black dashed line). (Simulations by J. Lewis.)*

determine whether and how much the road network continued to have an influence on which small towns were fortified in later periods.

Despite the limitations, it has been shown that the connectivity of the Roman road network played a fundamental role in which small towns were defended during the 2nd c. The provision of defenses around small towns and the association with the protection of the administrative infrastructure reflects the importance of the *cursus publicus* in the establishment and maintenance of Roman rule within the Roman province of Britannia.

Declaration of Competing Interest: The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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