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The afterlife of Roman roads in England: insights from the fifteenth-century Gough map of Great Britain

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ABSTRACT

This paper presents a new Geographic Information Systems database of travel and communications routes in England and Wales derived from medieval cartographic evidence. We argue on the basis of archaeological, physical landscape, onomastic, documentary, cartographic and other historical evidence that the network of red distance lines on the Gough Map of Great Britain, dated *c.* fifteenth century, represents travel routes and roads connecting medieval settlements. As such it constitutes the earliest depiction of a British network of medieval overland routes at a reasonable level of complexity and geographical extent. Taking this as a very partial, but important, sample of the fuller medieval travel networks, we investigate which elements were carried over from the road network of Roman Britain. Using a selection of computational and qualitative methods and approaches, we thereby evaluate the character, regionality and relative quantity of Roman routeway survival, shedding light into the complex transformations of human landscapes that occurred both at macro (national) and micro (regional, local) scales across approximately one thousand years.

1. Introduction

Medieval England was no different from contemporary western Europe in having a road network created through several millennia of movement. Prehistoric routeways, Roman roads, and early medieval 'army-paths' (referred to as *herepæð*, *herestræt* or *hereweg* in Old English texts: Grundy, 1918, 70–72; Baker and Brookes, 2013, 140–152) all contributed to the formation of a dense palimpsest of communications. Recent work, as part of the Leverhulme Trust funded project *Travel & Communication in Anglo-Saxon England* (RPG-2014-074; Brookes et al. forthcoming) has gone some way towards better understanding the development of this route network. By drawing together historical, archaeological, landscape, linguistic and literary sources it has been possible to define a model of the medieval travel infrastructure, including the chronological horizons at which individual routes are attested.

In this paper a comparison is made between this model of medieval routeways and features depicted on the Gough Map of Great Britain (MS Gough Gen. Top 16, and see the interactive and annotated high-resolution online edition by Linguistic Geographies[1]), namely the 'red lines' drawn between a number of settlement icons across England and Wales. It is argued that these 'red lines' correlate closely to medieval overland routes, which they therefore likely depict. This observation provides for important insights into the composition of the English route network at a specific moment in time. We can demonstrate that a very significant portion of the Gough network consisted of Roman routeways. These results are presented in a new Open Access Geographic Information Systems (GIS) database of the Gough route network (see Fig. 2), based on interdisciplinary archaeological, documentary, onomastic and cartographical research (Oksanen and Brookes, 2024 [2]).

Analysis of our GIS evidence allows us to identify specific Roman route sections that either survived or disappeared during the Early Middle Ages (400–1100 CE). As we will discuss, these observations can be in turn used to contemplate on the large-scale processes that influenced the long-term survival of Roman routes in England, as well as the development of new medieval portions to the transport network.

Importantly, the principal quantitative (e.g., computational analysis of the relationship of archaeological stray finds with routes) and

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[1] The Gough Map of Great Britain: https://goughmap.bodleian.ox.ac.uk/.

[2] Part of the ADS Special Collection on medieval travel and communications infrastructure at Early Medieval Atlas Projects: https://doi.org/10.5284/1055092.

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qualitative (e.g., place-name research and close landscape reading) methods deployed are highly transferable to other geographical contexts where similar data exists or can be collected. Our case study therefore provides a model for developing and interrogating an interdisciplinary Open Science database in historical travel and communications studies, and a way of bringing together a selection of mutually supportive methodological approaches—worked out and tested in previous publications, including those published by the authors—to study diachronic change in large-scale transport infrastructure networks in a reproducible manner.

2. Material and methods

The Gough Map, so named after Richard Gough who bequeathed it to the Bodleian Library, Oxford, in 1809 CE, is one of the oldest surviving maps of Great Britain (Fig. 1). The cartographer (or cartographers) are unknown. The map is 115 cm × 56 cm in size on vellum, and depicts the coastline of the island of Great Britain, several smaller islands and parts of the coastlines of Ireland and the Continent. Rivers are shown, and over 600 cities, towns and smaller settlements are represented by churches, fortifications or simple houses. Conventionally dated to *c*. 1360–70 CE, it has been suggested on palaeographical grounds that the map was made one or two decades after 1400 CE (Smallwood, 2010). There is evidence that portions of the map were redone and that work on it probably continued into the fifteenth century (Delano-Smith et al., 2017; Solopova, 2012). The Gough Map is a unique and important survival, predating the next major cartographic work of overland routes (as we will argue) by some two to three hundred years.

2.1. The 'red lines'

One feature of the map that has excited great interest among historians of the Middle Ages are the so-called 'red lines' that connect together many of the depicted settlement icons (Figs. 1 and 2). These lines seem to schematically designate major roads, and are in most cases accompanied by a roman numeral indicating the mileage between two settlements. Given that the lines chart out significant sections of such important medieval thoroughfares as the Great North Road and Watling Street (Taylor, 1979; Hindle, 2008; Oksanen, 2015), and also given the Gough map lines' remarkable correspondences to the roads in John Ogilby's atlas *Britannia* of *c*. 1675 CE (Ereira, 2016), scholars have traditionally taken these red lines to represent a network of contemporary routes (e.g., Hindle, 2008, 31–35; Stenton, 1936). More recently, however, there has been disagreement on this issue, and it has been argued that the lines are more akin to distance lines representing a sense of connectedness between settlements (Delano-Smith et al., 2017, 15–18; see also Delano-Smith, 2006; Millea, 2007, 2008).

Certainly, if the lines are routes the record is not comprehensive, nor 100 percent exact. Significant omissions include the route from London to East Anglia via Colchester, and Watling Street between Canterbury and London, although the antiquity of the latter has been questioned (Tatton-Brown, 2001). It has been pointed out that the direct line between York and Market Weighton appears somewhat illogical since the route passes by Pocklington, which is also connected by red lines to both of the former (Delano-Smith et al., 2017, 15). A Roman road (Margary, 1973), route no. 2e), however, passed south of Pocklington and provided a probable alternative route between the two other towns that did not require passing through the third, which could explain the map's arrangement. There is also at least one clear instance of a water route where a red line bends to trace the shape of the River Witham from Boston to Lincoln (Oksanen, 2019). But these peculiarities (if arguably not the omissions) are quite minor in the overall scheme, and as the Gough routes and roads database shows clear comparisons can be made between nearly all depicted red lines and other evidence for early routeways.

Amongst the evidence we have examined are the physical archaeological remains of roads and other transport infrastructure such as bridges (see also Harrison, 2004), though these are nevertheless subject to interpretative constraints. For example, even when combined with evidence drawn from aerial, geophysical and archaeological surveys, archaeological remains are relatively rare occurrences, providing only small sections of the total historical transport network. In local studies these segments are often extrapolated outwards using other features of the modern landscape — such as roads, unmetalled tracks, field boundaries that preserve the alignments of earlier routeways — to reconstruct transportation networks. Recourse must therefore also be made to more intangible evidence, such as administrative boundaries, place-names, and written accounts, that describe these early routes. All these sources of evidence contribute to our digital reconstruction of the route network, and require a number of complementary methods and practical assumptions spanning the disciplines of archaeology, cartography, place-name and historical research.

2.2. Digitization

In reconstructing the early medieval communications system the *Travel & Communication* project was able to draw on a range of previous scholarship and datasets. Significant work has been carried out on the Roman Roads of Britain, first, by Ivan Margary (Margary, 1973), who used archaeological and cartographical methods to identify Roman roads, that have now been digitised, and second, by a range of local studies (cf. RRRA, n.d.). Digital maps of these Roman roads have been published by the Ancient World Mapping Centre.[3] To these the *Travel & Communications* project has added data on medieval place-names relating to travel, such as the element *strǽt* meaning 'main/paved road' which was seemingly used to identify Roman roads by Old English speakers (Gelling and Cole, 2000, 93–94; Cole, 2013, 17–23; Langlands, 2019, 137–143).

Other early medieval routes can also be evidenced by place-names, as shown by the work of Ann Cole and others (Cole, 2013; e.g. Taylor, 1979, 89–91; Hindle, 1993, 5). Through direct reference to elements of infrastructure and nodes of transportation, and through reference to activities, features or objects that might be presumed to have an association with travel and communication routes, place-names are able to flesh out our knowledge of early routeways (see Brookes et al., 2019 for a similar reconstruction of medieval bridges and fording points, and Oksanen, 2017, 2019 for navigated inland waterways). Written sources containing toponymic material predating the Gough map are varied. Notable are early medieval charter boundary clauses dating mainly to the tenth and eleventh centuries CE (Jenkins, 2001), and Domesday Book, a great survey of England and parts of Wales completed in 1086 CE after the Norman Conquest of England (Williams, 2001). Together these can offer a wealth of information on local and regional transport routes.

Our digitization process began with the identification of the red lines on the map and the settlements they connected. The Linguistic Geographies online edition of the Gough Map (see Fig. 1, and Delano-Smith et al., 2017) contains a highly useful annotated catalogue of both, although it is not without some minor errors, e.g., it overlooks the line connecting Oxford and Abingdon. All connected settlements were mapped into a GIS point dataset; to facilitate future interoperability and reuse coordinates were largely taken from the 1334 CE Lay Subsidies dataset by Barry et al. (unpublished; see Campbell and Bartley, 2006)

[3] AWMC: https://awmc.unc.edu/. We would also highlight the forthcoming Roman road data opened by Itiner-e as a major knowledge update on an Empire-wide scale: https://itiner-e.org/. This data has not yet been made fully available for GIS analysis at the time of this writing, but examination of the already opened online gazetteer indicates that there appear to be no significant differences between it and the data we have used for mapping the Gough Map-specific route sections.

Fig. 1. The Gough Map, with the 'red lines' highlighted in yellow. Data and image: Linguistic Geographies and The Bodleian Libraries, University of Oxford, goughmap.bodleian.ox.ac.uk. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

and the connected *Digital Gough* resource produced by the *Mapping the Realm* project (Lilley et al., 2009; Lloyd and Lilley, 2009). In those areas not covered by the subsidy assessment coordinates derived from the Taxatio database (tax assessment of ecclesiastical properties carried out in 1291–2 CE: Denton et al., 2014) were used.[4] The schematic network of map lines was then replicated by joining the points with vector lines.

The major interpretative work was in identifying the historical routes and roads that the red lines may have corresponded to. Each individual connection between settlement icons was visually inspected against three principal route datasets (of Roman and Early Modern roads, as well as of medieval place-names, bridges and other data related to travel infrastructure) to ascertain whether a close spatial fit could be identified.

Here the evidence from archaeology and place-names was combined with map regression. This process begins with matching dated evidence (e.g., medieval place-names, charter boundary data) of sequentially older routes to known map features of later date, such as vector line data of Early Modern roads. From the starting point of modern georeferenced cartography, we can strip back features to nineteenth-century, seventeenth-century, or earlier dates to create accurate mapping of relict features at different chronological layers. A particularly important source in the reconstruction was the *Turnpike roads of England and Wales 1667–1892* GIS dataset primarily drawing upon John Cary's *New Map of England and Wales,* published in 1794, cross-referenced against the road network depicted in John Ogilby's *Britannia*, published in 1675 (Rosevear et al., 2023).[5] By identifying features common to both earlier and modern maps, networks of routeways can be correlated with archaeological features and toponymic evidence to provide fixed dates.

These various methods allow us to define a dynamic phased model of routeways existing in medieval England and Wales (Brookes et al. forthcoming), bookended by the digitised data of Roman and Early Modern routes published by others (i.e., Ancient World Mapping Centre; Rosevear et al., 2023). The medieval networks of roads can in turn be compared with the red lines depicted on the Gough Map. By this method we have been able to match 99 percent of the red lines on the Gough Map with historical routes that connected settlements. The resulting network has been developed into an Open Access GIS database (Oksanen and Brookes, 2024), shown on Fig. 2 along with medieval inland waterways for which there is evidence of navigation until the fourteenth century (Oksanen, 2019).

From this analysis it is clear that the Gough Map contains a limited (but significant) sample of the medieval route network, with some odd gaps between even nearby settlements. In this paper we do not seek to participate in the recent discussions about the rationale for selection of the lines (and therefore, as we have shown, the routeways) included in the map. It is of interest, however, that combined with known navigated medieval rivers and canals (as initially identified in Edwards, 1987; debated in Edwards and Hindle, 1991; Langdon, 1993; Jones, 2000; revised and expanded into a GIS database in Oksanen, 2017, 2019) the picture of a travel network is rendered more meaningful. Navigable waterways join together the red lines in Lincolnshire with north-south cross-country routes, and connect London to the Channel coast and beyond (as also pointed out in Pablo-Martí et al., 2023).

Further supporting the idea that the Gough Map represents a real depiction of the medieval transport infrastructure is its relationship to known medieval urban and commercial centres (Fig. 3). A selection of the 50 most important English towns in the fourteenth century (Dyer, 2000: 755–757), supplemented with market towns valued with at least £300 in taxable assets in 1334 (Barry et al. unpublished; see also Campbell and Bartley, 2006), shows that, with only a handful of exceptions, all are linked by a major transport artery in the form of a Gough route, a navigable river, or the coast. It seems clear, therefore, that despite some local eccentricities, the 'red lines' of the Gough Map are solidly rooted within the transport geography of medieval England. Although the map does not depict the whole network, our stance is that it nevertheless represents a meaningful sample that can be further examined to define its contributing characteristics.

3. Results

This sample can now be used to shed light on the long-term development of the English travel network up to *c.* 1400 CE, with methodological implications for the study of historical travel and communications routes in other contexts. In our GIS database (Oksanen and Brookes, 2024) the identified historical road lines were divided into short segments and matched with the available chronological evidence. As a rule of thumb segment division was done at major road intersections or settlements. Therefore, archaeological or place-name evidence would demarcate and date a road segment only between two such nodes. For longer cross-country sections the segments could be up to a few dozen kilometres long, whereas near towns and transport nexuses that were surrounded by a complex cluster of routes a road segment might be only a few hundred metres; the mean length for all main chronological periods is less than 10 km (see Fig. 3). The much shorter

[4] Taxatio: https://www.dhi.ac.uk/taxatio/.

[5] CAMPOP: https://www.campop.geog.cam.ac.uk/research/occupations/datasets/catalogues/documentation/turnpikeroads16671892.pdf.

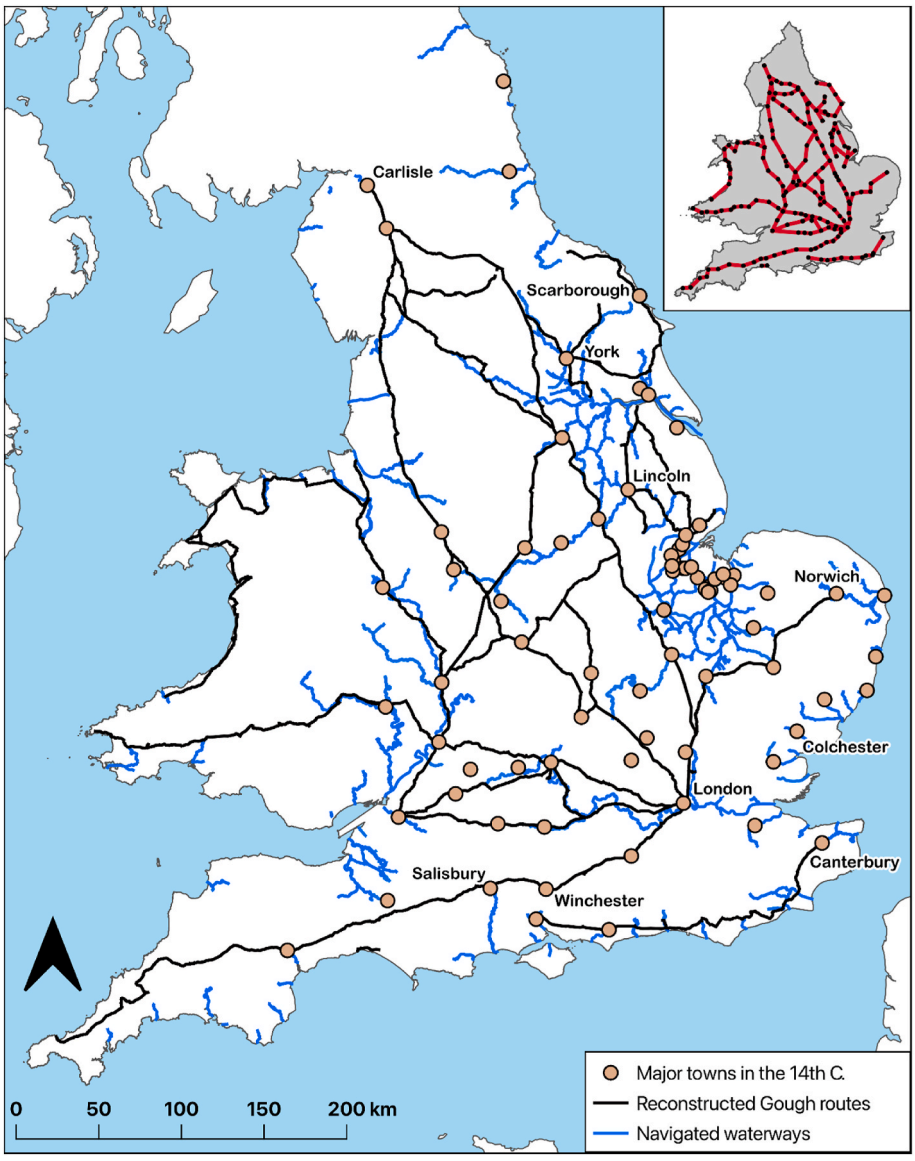

Fig. 2. A reconstruction of the roads of the Gough Map combined with known navigated inland waterways and large urban/commercial centres in the fourteenth century. A selection of towns mentioned in the text are labelled. The inset depicts the network of red lines and marks the settlement symbols they connect. Data: Oksanen 2019; Oksanen and Brookes 2024. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

lengths of the less than dozen undated (i.e., modern only) road segments is a reflection of the fact they were required only to patch small gaps in the evidence base. The only exception of any significant length (represented as the top outlier of the 'Modern' category violinplot in Fig. 3) is the north-eastern coastal road from Bridlington via Scarborough to Whitby and then inland to Guisborough; it is possible the first stage may have in fact marked a sailing route and not a physical road (see Fig. 2).

It must be noted here that we are not proposing that a specific route must have followed the exact path of a physical Roman road. There are, indeed, many examples where the medieval road ran parallel to an older track, intersecting with its specific line only at river crossings or where the lay of the terrain pushed intertwined pathways together (Hindle, 1993, 23). The most famous example may be the Icknield Way, an escarpment 'route' running roughly along a north-east to south-west diagonal from Norfolk to Berkshire and beyond to Wiltshire. It has been used since prehistoric times as a broad corridor of linear communications, comprising a bundle of parallel routeways (Dyer, 1989, 345; Fowler, 1998, 30; Harrison, 2003, 1) in which Roman routes (e.g., Margary, 1973, routes nos. 168a, 168b, 333) formed but one thread in the skein. Indeed, the wear and tear of millenia on a paved Roman road could make it highly unsuitable for wheeled or animal traffic. We are, therefore, making a distinction between a physical road line and a historical routeway, the latter being a more generalised passage through a landscape that was subject to evolution across centuries, but which nevertheless provides critical information on the infrastructure, its relationship with demographic patterns, and the local experience of travel.

The results of our analysis show that in the sample of route lengths captured by the Gough Map, almost a third can be securely and independently dated to the medieval period by the aforementioned evidence (e.g., archaeology, place-names, charter boundary clauses). Of the rest, about one third are of known Roman routes (pre-410 CE, some of these having possibly originated as prehistoric trackways). For another third there is no evidence for them predating the Early Modern period (1540–1800 CE), although the Gough Map indicates they were medieval as well (Table 1). Indeed, it should be noted that each category above 'Early Modern' represents the minimum verifiable proportion of routes from that time period as it is possible that, for example, some 'medieval'

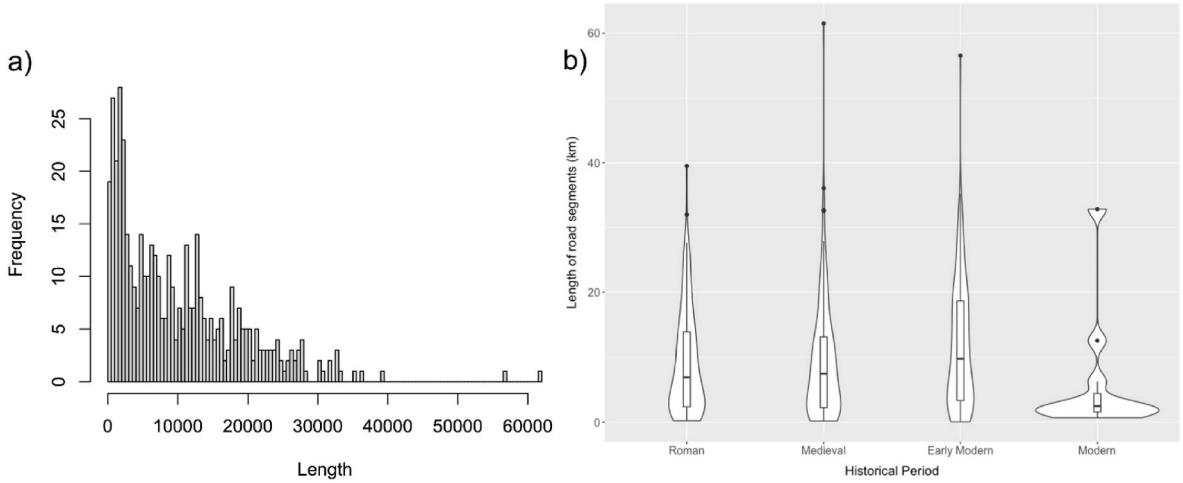

Fig. 3. The distribution of all road segments (n = 455) lengths as a) histogram and, divided into main chronological periods by oldest possible dating outside the Gough Map itself, as b) violin plot combined with a boxplot. Data: Oksanen and Brookes 2024.

Table 1
Evidence contributing to the dating of the Gough routes by chronological period, outside the map itself. The percentage values do not add up to exactly 100 percent, as they have been rounded to the nearest decimal. Data: Oksanen and Brookes 2024.

DESCRIPTION	N of segments	Length in km	Percentage
Roman routes	172	1611.7	35.5 %
Early medieval (pre-1086)	60	593.3	13.1 %
Post-Domesday Book (1086)	87	734.7	16.2 %
Early Modern	124	1474.9	32.5 %
River Witham	1	61.5	1.4 %
No historical route line	11	65.8	1.4 %
TOTAL	455	4542	–

routes are currently unrecognized Roman routes.

As can be seen from Fig. 5, the Roman routes that continued to be in use through the Middle Ages are present in most parts of England, from the southern coast to Carlisle in the north-west. Nevertheless, there are some regions where the medieval reorientation of the Roman network is more substantive than in others: for instance, in the western Midlands. In other parts, such as the Welsh coast, the presence of the Roman road network is difficult to ascertain in the first place.

A more temporally nuanced appreciation of these dis/continuities can be gained by comparing the Gough roads with the distribution of hundreds of thousands of datable small finds that have been discovered by members of the public in England, mostly by using metal-detectors to search for metal objects on ploughed agricultural fields. The Portable Antiquities Scheme in England and Wales (PAS) records these objects, and its database has published over 1.7 million finds records, including over 193,000 Roman era (43–410 CE) and over 70,000 central to late medieval (1066–1540 CE) coin finds with good spatial findspot data.[6] This material represents a considerable, though still unevenly exploited, reservoir for archaeological and spatial examination of the English and Welsh pasts (see Leahy and Lewis, 2018; Lewis, 2023; for explorations of quantitative applications on the PAS data see e.g., Bevan, 2012; Green et al., 2017; Oksanen and Lewis, 2023).

[6] Website: https://finds.org.uk. Data obtained 29.06.2023. The coin finds data cited was first cleaned so as to remove finds with spatial precision of less than 6-figure National Grid Reference (findspot located within a 100 m square), as well as records ingested by the PAS database from the Celtic Coin Index, Iron Age and Roman Coins of Wales and the Iron Age and Roman Hoards projects, which were recorded using different standards and represent e.g., excavations finds and not metal-detected single coin finds.

We have calculated the proximity of Roman and medieval coins to known Roman and medieval road segments in the Gough Map using the *rhohat* function in the R package *spatstat* (Baddeley et al. 2012, 2022). This computes a nonparametric estimate of the intensity of a spatial point process (here the distribution of findspots) in relation to a continuous spatial covariate (distance from roads). Our study areas are located within a 10 km radius of different chronological subsets of roads attested in the Gough Map (Roman and medieval), as defined above. The results represent aggregate analyses, therefore illustrating broad trends at a national scale. Within these areas, the rhohat analysis clearly demonstrates that medieval coin finds as a group concentrate in the near vicinity of Gough routes attested from medieval evidence. This suggests a spatial relationship between movement infrastructure, demography and economic activity, as might be expected (Fig. 4). Medieval coins are also concentrated near former Roman routes depicted on the Gough Map red lines, supporting their continued use during the Middle Ages. We note the upwards ticks in the first half a kilometre in all the graphs is probably due to the minimum possible spatial granularity of the analysis (4-figure National Grid Reference, or 1000 m × 1000 m square, precision), and also the fact that metal-detectorists usually do not cover the fields that they search evenly (Robbins, 2012).

Slicing the corpus of coin finds into shorter periods refines this chronological pattern. The coin periods have been selected as follows on the basis of significant socio-economic developments and major monetary reform periods that removed older generations coins from circulation: 600–800 CE (the era of Middle Saxon *sceat* coinage); 800–973 CE (post-*sceat* until King Edgar's coin reform of 973 CE); 973–1180 CE (to the introduction of Short Cross coinage by Henry II); 1180–1351 (to Edward III's coin reform at the time of the Black Death); 1351–1544 CE (until the Great Debasement under Henry VIII) (Williams, 2008; Allen, 2012). This diachronic comparison, discussed further below, reveals a pattern of increasingly significant spatial association between medieval-period routes and medieval coin finds: from around 1000 CE onwards the distribution of finds clusters increasingly clearly to the immediate vicinity of the route network as it is depicted in the Gough Map. We interpret this as signalling the development and consolidation of the medieval overland travel and communications network in response to the demographic and socio-economic developments of the High Middle Ages.

4. Discussion

It is now worth restating the fundamental observation, that routeways in the landscape represent a significant and long-term

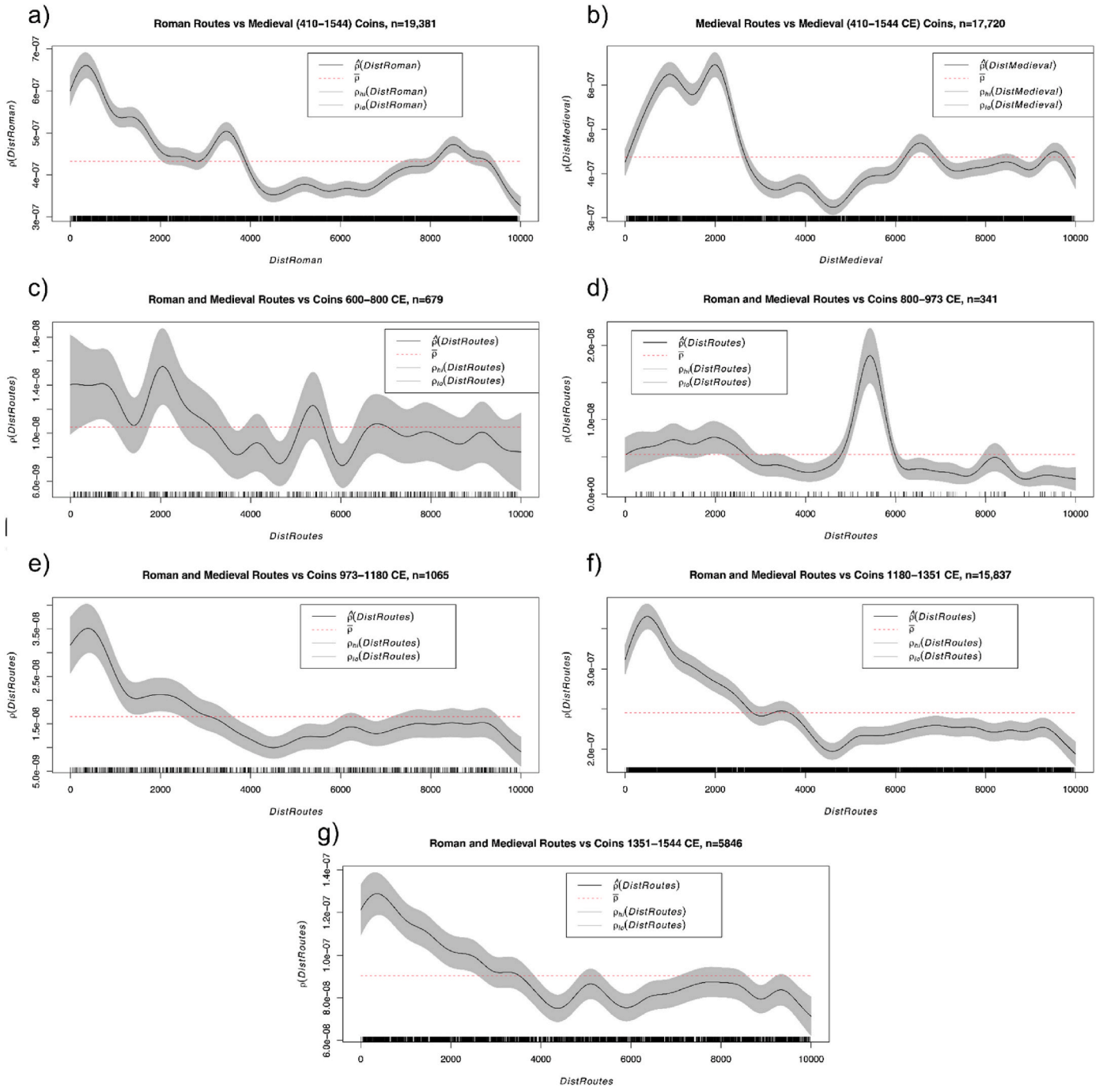

Fig. 4. Rhohat functions contrasting the distribution of: a) medieval coins against former Roman routes attested in the Gough Map; b) all medieval coins against routes evidenced from medieval evidence; and c) – g) combined Gough routes from the Roman or medieval periods against coins from medieval coin periods. At distances from digitised roadlines (metres on the x-axis) where the function line rises above the horizontal dotted red line, a higher concentration of coin observations occurs than would be probabilistically expected if there was no spatial correlation between findspots and the distance to roads. The spatial resolution of the data is 4-figure UK National Grid Reference (1000 m × 1000 m square). The grey envelope describes a 95 percent confidence interval, therefore the results are significant only at distances where both the function line and the surrounding envelope are clearly above or below the dotted red line. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

infrastructural development — often resulting from direct investment through construction and maintenance efforts — that echoe, enable, and (once established) constrain wider demographic and socio-economic changes. The study of route networks can therefore be used to explore a variety of spatial processes, at multiple scales. In this paper we have described the contribution that different phases of infrastructure building have made to the English road network of the fifteenth century. In trying to explain why some stretches of Roman roads or routes survive and others do not, several general drivers of change can be proposed. In some cases such individual processes are dominant, but more often they overlap and reinforce each other. Acknowledging this fact, three factors are discussed in turn.

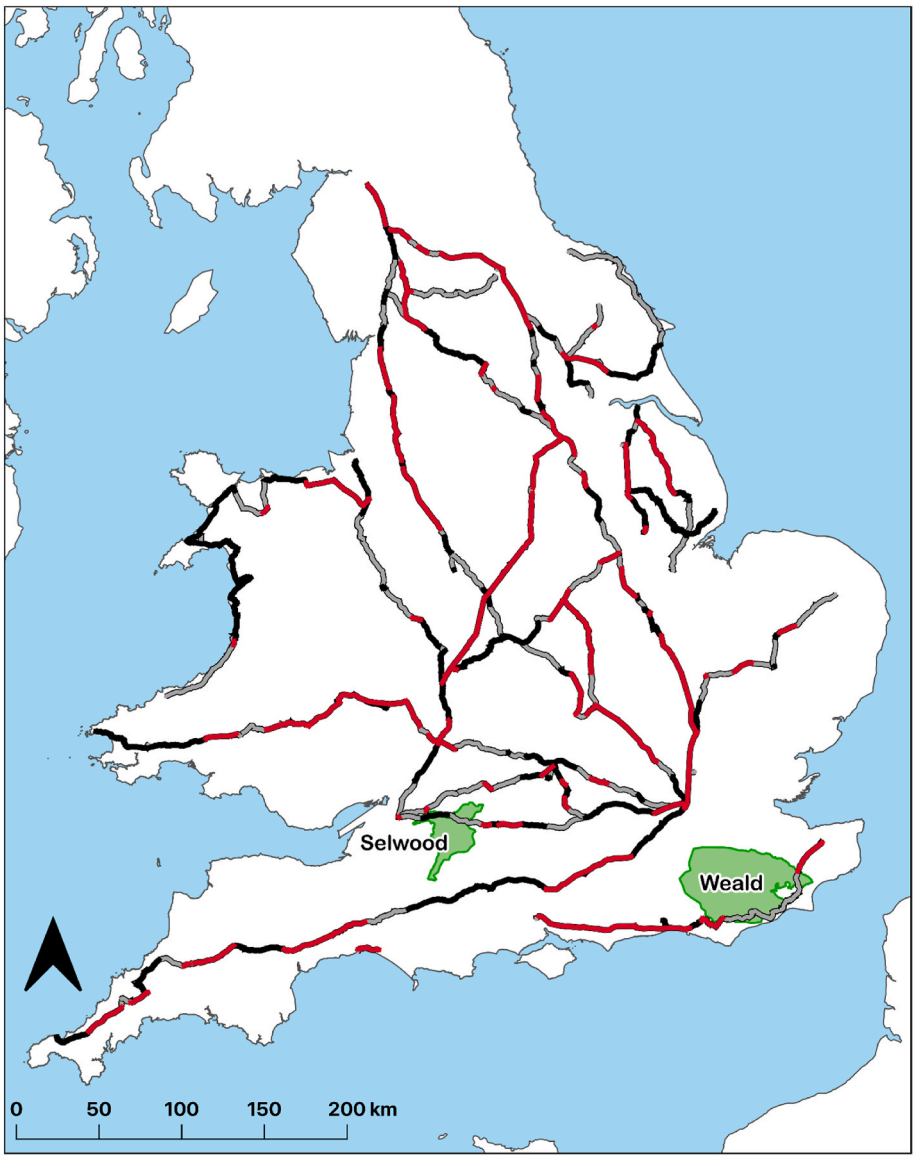

Fig. 5. Route segments associated with known Roman roads (in red) on the Gough Map. Those sections that are confirmed by other medieval-era evidence are depicted in black, the rest in grey are largely based on Ogilby and Cary roads. The historical Weald and Selwood forests are shaded in green. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

4.1. Regionality of early medieval political power

The first can be conceived as broad historical processes, concerned with the regional fragmentation of political power in the late Roman and early post-Roman periods. A wide range of sources make it abundantly clear that the fifth and sixth centuries witnessed a political, social and economic dislocation after the end of Roman imperial rule in Britain, in which rulership contracted into 'small worlds' of local kin- and client-based power structures (Gerrard, 2013). While by the later sixth century, through competition and conflict with their peers, some of these local rulers were able to impose their authority more widely, establishing patterns of territorial lordship and regional hegemony which appear in the documentary record as the earliest Anglo-Saxon kingdoms (Bassett, 1989), these new political entities remained agglomerations of earlier small-scale units.

Given these social and political developments it is clear that local geography and environment often played an important structuring influence. Various authors have explored the ways that these 'small worlds' of early groups mapped onto the *Siedlungskammern* 'settlement chambers' created by soils, drainage and landcover (e.g. Everitt, 1977; Phythian-Adams, 1993; Williamson, 2013; Scull et al., 2024). Thus, for example, we find that the kingdoms of Mercia and Deira focussed on the major drainage systems of the rivers Trent and Yorkshire Ouse respectively.

Between these political entities were boundary zones initially populated by de-centralised but localised groups that were brought under political authority over time. One such natural break-point was the great Selwood which formed part of what is now the border between Wiltshire and Somerset, and would seem in the fifth to seventh centuries to have demarcated a regional polity centred on Bath from West Saxon controlled areas to the east (Eagles, 2022). Another was the great woodland known as the Weald which separated the kingdom of Kent from that of the South Saxons (Everitt, 1986). In both cases we find that the Roman roads through these woodlands do not survive as Gough roads, perhaps indicating that movement through these borderlands between kingdoms became less common, at least for a time (Fig. 5). By contrast Roman roads within the heartlands of kingdoms — within Wessex, Kent, or Mercia — persist to a much greater degree. Here one

might conceive of a general continuity in settlement and land use, even if early medieval sites did not map directly onto those of Roman times.

4.2. Environmental and agricultural processes

A second related factor that influenced continuity and discontinuity of the Roman road network is the ground itself. At a very large scale it appears that there are correlations between surviving (or not surviving) stretches of Roman roads and different types of soil geology. There seems, for example, to be a better rate of preservation of older routes when these run over chalk downland as opposed to heavier clay soils (Fig. 6). At least two explanations for this phenomenon can be suggested. Firstly, it might be relevant that on free-draining soils, routes will usually remain useable despite minor erosion, whereas heavier waterlogged soils require users to maintain the artificial surface in order for the route to remain passable. If surfaces are not adequately drained and kept clear of excess vegetation, or artificial surfacing maintained, they might quickly become unusable. Indeed, similar processes relating to road survival must have been powerfully influenced by local circumstances and agency. For example, in numerous cases, the alignments of Roman roads are maintained by later routeways, but divert when they approach river crossings, in all likelihood because the Roman bridges over these rivers were no longer extant. Instead, medieval travellers sought out easier pedestrian crossings (fords) up or down stream from former bridges (cf. e.g. Baker and Brookes, 2013, 296–299; Langlands, 2019, 75–77).

Secondly, changes in farming practices across the medieval period affected some places more than others. Generally speaking, pastoral uplands witnessed a greater continuity in farming than the champion lands of the central province — comprising heavier and stickier, but ultimately more fertile, soils — where between the tenth and twelfth centuries more dispersed patterns of settlement were nucleated into villages surrounded by open fields (Roberts and Wrathmell, 2000, 5, 42–3, 49; Williamson et al., 2013, 192–3). This radical reorientation of settlement is likely to have differentially affected the survival of Roman roads — that no longer went where people wanted to go, and were diverted around, for example, new fields that were being established (Fig. 7). Such effects would seem, however, to have been highly localised. Even within the central province, there is an important mismatch between agricultural need, local requirements, and response, so while there is a general tendency towards change, it is limited to fine-grained decisions and local agency that are not easily picked up in macro-scale analyses.

4.3. Urban reorganisation

A third point that emerges is that the transport network shifted to accommodate changes in the economic landscape of post-Roman Britain. In a recent article we contrasted the structure of Roman and medieval communications in England by identifying the different hierarchies of nodal points within the road and river networks using the Google PageRank algorithm (Brookes and Huynh, 2018; Oksanen, 2019). To summarise, a major finding was that there was a significant shift in the overall structure of the transport network between the second and twelfth centuries. The central locations in the Roman network structure tended to be located further inland, presumably reflecting its origins in the military and administrative organisation of the province. The exceptions are the Essex and the Somerset coasts on the main vectors of continental connections via the Thames and Severn estuaries. By contrast, a larger proportion of well-connected places in the medieval network structure tended to be located near the coasts, or if inland they were along major river routes directly connecting to the sea. This conforms to a picture in which the medieval economy of England was more geared towards water transport (Blair, 2007; Oksanen, 2022).

The rhohat analysis, described above (Fig. 4), shows that archaeological public finds until the end of tenth century do not cluster as clearly near the routes of the 'medieval network' as it had developed by the fifteenth century. While there is already some positive correlation between early medieval coin findspots and nearness to routes, this is expected from continued reuse of some Roman routes. Very likely it also owes to the modern recovery of bias in metal-detectorists often searching in areas that are near modern roads (Robbins, 2012: 147, 188, 224). This correlation, however, is nowhere near as even as it emerges from the eleventh and twelfth centuries onwards, and by the thirteenth century the probabilistic spatial relationship of coin finds to routeways represents a clear slope.

We argue that our findings fit into and create new insights regarding long-term processes of economic and urban development. Indeed, it could be speculated that there is some contraction in travel during the fifth to eighth centuries, with the formalisation of new routes around

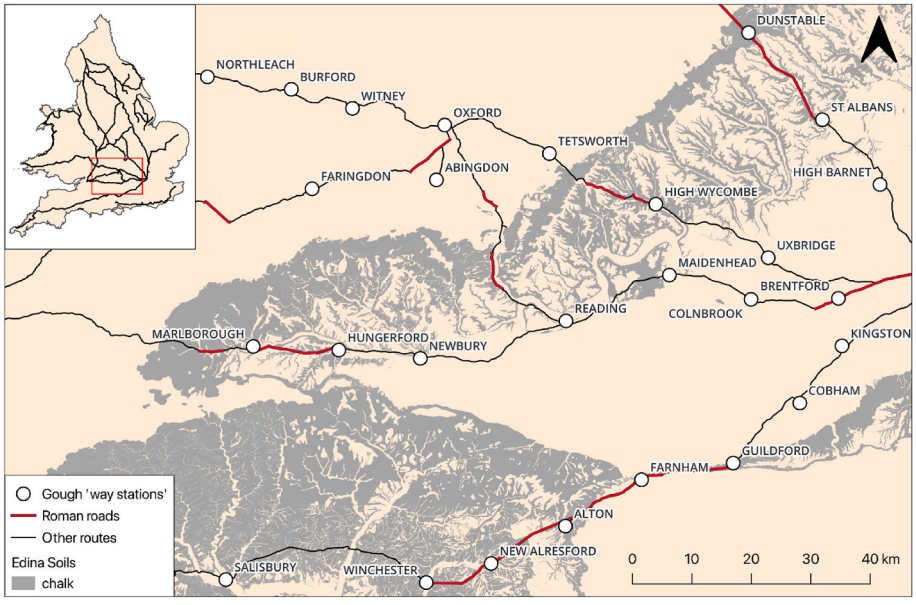

Fig. 6. An example of the differential continuity and discontinuity of Roman roads in the Gough map, in the region due west of London. Surviving Roman routes correlate particularly well with chalk soils. Data: Edina Soils, Oksanen and Brookes 2024.

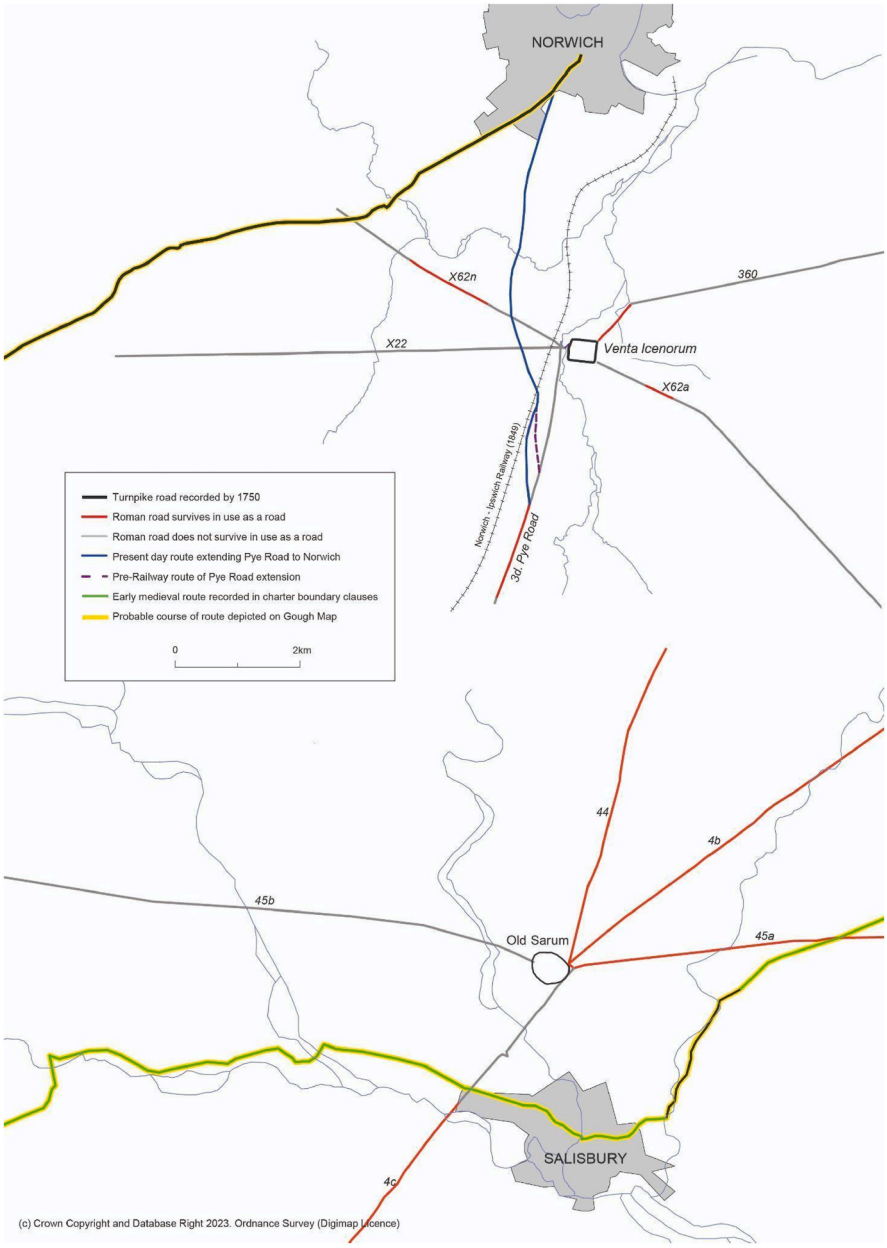

Fig. 7. Examples of the reorientation of transport infrastructure of two Roman towns and their medieval successors: (above) Caistor (Venta Icenorum)-Norwich (below) Old Sarum (Sorviodunum)-Salisbury. Roman roads as defined and numbered by Margary 1973.

reorganised demographic landscapes only gathering apace from the ninth century onwards and consolidating during the eleventh and twelfth. The strongest relative growth in the association of coins finds with medieval roads appears during the fourth chronological period (1180–1351 CE), and can be further located to the twelfth and thirteenth centuries. This was a time of significant commercial growth accompanied by numerous new market foundations near cross-country routes, as well as infrastructure investment such as bridge building. It established a durable spatial pattern that even the demographic catastrophes of the fourteenth century would not shift (Broadberry et al. 2015; Campbell and Bartley, 2006; Harrison, 2004; Letters, 2003; Oksanen, 2015).

Intriguingly, the analyses using all medieval coin data against Roman and medieval routes (Fig. 4a and b) also show slight probabilistic increases at distances of between *c*. 6 km and 9 km from the nearest Gough route. Analysis with a larger finds dataset containing newer, unpublished finds data and more precise coordinates—which is not made public by the PAS but can be requested for research purposes by signing a data release agreement—further increases the clarity of these patterns. Based only on this analysis the probabilistic increases are difficult to explain conclusively, but our initial interpretation is that in aggregate they reflect a second rank of (often smaller) commercial sites located some distance from those on Gough routes. An English medieval small town's economic hinterland has been estimated to be at least 9–12 km, but these spheres of commercial interest were neither spherical nor exclusive, but rather overlapping and distorted by transport geography (Dyer, 2002: 13–14). Moreover, other small commercial events such as local markets or fairs existed in the gaps between high and late medieval towns, and from the late twelfth century onwards developed into robust commercial networks covering large parts of the kingdom (Britnell, 1981; Masschaele, 1997; Oksanen, 2015). On the basis of this we would indeed expect to detect signs of their presence at the upper half of our distance scale. This spatial statistical analysis of metal-detected coin finds — data that is increasingly available internationally in several European countries (e.g., Wessman et al., 2023 for several examples) —

may therefore provide a way by which future research can refine our understanding of the catchment zones around commercial sites and their impact on medieval economic development at regional scales.

The chronology supports the thesis that by the time of the Gough Map in *c.* 1400, these new 'medieval' routes — formalised around the start of the second millennium CE — had become an essential component of the transport infrastructure. Indeed, it may even be possible that during this same period of infrastructural infilling some formally disused Roman road segments were reincorporated into the system, as might be suggested by the comparison of plots in Fig. 4 (on this point cf. also Langlands, 2021, 46–54). Taken together with the observation that the medieval settlement pattern was linked to riparian and coastal transport nodes (Brookes and Huynh, 2018), these findings add further weight to the suggestion that the high and late medieval English transport network as it developed from around 1000 CE onwards exhibited a deep, long-term and systemic connection with overseas trade — more so than what appears to have been the case in the Roman period.

5. Conclusions

At its most basic level this work has added to that done by previous digitization projects (e.g., Delano-Smith et al., 2017; Lilley et al., 2009; Lloyd and Lilley, 2009), producing an Open Access database that focuses specifically on the Gough Map as capturing elements of medieval travel. The analysis of this database goes further to show the potential (already proposed in Brindle, 2014 in England and further explored e.g., by van Lanen et al., 2015 in the Netherlands) to deploy large-scale archaeological data for modelling historical routes and settlement areas. We argue that a GIS-based analysis of one sample of the route and river network (that is represented by the Gough Map 'red lines'), supported by closer readings of specific landscapes, is able to draw out significant large-scale socio-economic patterns that explain important long-term developments in the formation of post-Roman England. These approaches in turn could be applied to any region where sufficient comparable data exists. We would underline that such critical and methodological considerations are particularly topical given the recent development of new collaborative European GIS resources for mapping and enriching information on historical travel infrastructure on transnational scales both in the Roman period (notably *Itiner-e: The Gazetteer of Ancient Roads*[7]) and the medieval period (notably *Viabundus Pre-Modern Street Map*,[8] Holterman et al., 2022; Holterman and Huang, 2023), as well as Early Modern road networks at national scales (e.g., Oksanen et al., 2023; Rosevear et al., 2023),

So far we have described a number of different factors that might explain the survival (or not) of Roman roads and routes into later times. At a macro scale, political, economic, and geological factors certainly had a part to play, but it would be wrong to see these in isolation from each other. For example, while the trend towards riverine over terrestrial transport might partially explain the lack of surviving Roman road stretches along the Thames corridor, this region also underwent significant political upheaval during the early medieval period, when it often formed a frontier between the early English kingdoms of Wessex and Mercia (Crawford, 1953; Blair, 1994, 55; Yorke, 1995, 62–64). Even so, on the chalk downlands flanking the Thames, stretches of Roman roads persisted.

Beyond the macro-scale processes there were local factors affecting towns and countryside throughout the Middle Ages. With the abandonment of urban centres in the post-Roman period it is certain that people were no longer accessing towns as frequently as they had in previous centuries, with a corresponding freeing up of town-focused patterns of mobility. Here the survival of Roman roads depended greatly on the afterlives of specific places. For example, near medieval towns such as London, Leicester and Winchester, which occupied the same locations as their Roman predecessors, there is good correspondence between the routes depicted on the Gough Map and earlier Roman roads. By contrast, routes near former Roman towns such as *Sorviodunum,* beside Old Sarum in Wiltshire and *Venta Icenorum*, Caistor St Edmund in Norfolk, that were replaced by new towns at Salisbury and Norwich respectively, survive only partially in the modern landscape and do not feature in the Gough Map (Fig. 7). For all stretches of Roman roads, survival depended on an interplay between broader macro-processes and particular local situations that were unique to each.

To conclude, in this paper we have described a sample of the medieval road network and its descent from Roman times. Using the red lines of the Gough Map as a proxy we have begun to quantify the contribution Roman roads made to the medieval road network in England, and to evaluate some of the spatial characteristics of the surviving sections. These developments are likely to be also reflected in other, continental, contexts and — as we have seen — depended on a range of large-scale factors including economic change, processes of urbanisation, and political developments, but also physical conditions of soil, agricultural production and landcover. But it is highly misleading to see the influence of any one of these as universal. Ultimately, route survival was the result of minute cumulative decisions made by medieval people on the ground. Within this continuum of change everywhere, there were different factors shaping mobility in the landscape, and different rates of transformation that resulted from these human decisions.

CRediT authorship contribution statement

Eljas Oksanen: Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Software, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Stuart Brookes:** Writing – review & editing, Writing – original draft, Visualization, Resources, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization.

Data availability

Data on historical Gough routes studied in this article has been published in Oksanen and Brookes 2024 and is available Open Access from the Archaeology Data Service [https://doi.org/10.5284/1124312]. The dataset Domesday Shires and Hundreds of England in the same archive [(Brookes, 2020): https://doi.org/10.5284/1058999] can be used as basemap for map visualization. PAS coin findspots data is owned by the Portable Antiquities Scheme in England and Wales [https://finds.org.uk/]. The findspot dataset used to produce Fig. 4 in this article is a daily database dump downloaded from the PAS website on February 28, 2025 and made available by the PAS under CC-BY license. For the convenience of replication, the authors have made it along with the R code used to produce Figs. 3 and 4 available on zenodo.org [https://doi.org/10.5281/zenodo.14953757].

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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[7] Itiner-e: https://itiner-e.org/.
[8] Viabundus: https://www.viabundus.eu/.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jas.2025.106227.

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