Landscapes

ISSN: 1466-2035 (Print) 2040-8153 (Online) Journal homepage: www.tandfonline.com/journals/ylan20

Exploring the Location of 'Ancient Woodland': A Statistical Case Study in Eastern England (UK)

Andrew Catherall-Ostler & Tom Williamson

To cite this article: Andrew Catherall-Ostler & Tom Williamson (2024) Exploring the Location of 'Ancient Woodland': A Statistical Case Study in Eastern England (UK), Landscapes, 25:1, 41-57, DOI: 10.1080/14662035.2024.2508042

To link to this article: https://doi.org/10.1080/14662035.2024.2508042

Published online: 27 Jun 2025.

LANDSCAPES
2024, VOL. 25, NO. 1, 41–57
https://doi.org/10.1080/14662035.2024.2508042

Routledge
Taylor & Francis Group

Exploring the Location of 'Ancient Woodland': A Statistical Case Study in Eastern England (UK)

Andrew Catherall-Ostler[a] and Tom Williamson[b]

[a]Homerton College, University of Cambridge, Cambridge, UK; [b]School of History, University of East Anglia, Norwich, UK

ABSTRACT
Statistical approaches and spatial modelling remain under-used in studies of the English rural landscape; patterns and associations in the historical environment have instead usually been treated in a subjective and impressionistic, rather than an objective and analytical, manner. In this paper we employ mathematical modelling to explore the relationship of ancient woodland to soil types and parish boundaries in eastern England. We argue that such approaches can serve to highlight relationships and associations that are not immediately apparent, as well as test the significance of those that have already been proposed, and that they should be more widely adopted in landscape history.

KEYWORDS
Ancient woodland; predictive modelling; Eastern England; Parish boundaries

Introduction

'Predictive modelling' using GIS (Geographical Information Systems) has been employed for several decades in archaeological research and cultural resource management, especially in the Netherlands and north America (Verhagen 2007; Verhagen and Whitley 2020). It is also common in the discipline of ecology (Franklin 2010), with some studies using a combination of ecological and historical datasets (Nolan *et al.* 2021; Żmihorski *et al.* 2020). Such statistical and spatial approaches have made less impact on the study of the English rural landscape; patterns and associations in the historical environment have instead usually been treated in a subjective and impressionistic, rather than an objective and analytical, manner.

Discussions of the locational characteristics of ancient, semi-natural woods, which have significantly informed the identification of examples for conservation purposes, are a case in point. It has long been suggested that such woods tend to occur on, or close to, parish boundaries (Peterkin 1981; Rackham 1976, 113). Indeed, adjacency to a parochial boundary was one of several criteria adopted for identifying ancient woods when the Ancient Woodland Inventory—the statutory list on which their protection is based—was first compiled, and is also being used in its current revision. But there has

CONTACT Tom Williamson t.williamson@uea.ac.uk School of History, University of East Anglia, Norwich NR4 7TJ, UK

been no real attempt to demonstrate statistically the strength of this relationship, nor to investigate other aspects that it might have, beyond the simple one of distance. In a similar way, ancient woods are said to occupy agriculturally challenging soils, but the strength of this association has not been tested nor its full character explored. In this short paper we examine these two aspects of woodland location in more detail, discuss their strengths as predictors of a wood's 'ancient' status, and note some of their implications for our understanding of woodland history.

Ancient Woods and Parish Boundaries

Ancient woods, technically those which have had an uninterrupted existence since before c.1600, are mainly 'primary' in character, that is, they have developed directly from the natural, post-glacial vegetation—the 'wildwood'. Only a small minority are 'secondary', that is, were planted or regenerated at an early date over abandoned farmland or settlements (Peterken 1981; Rackham 1976, 1980; Spencer and Kirby 1992). The overwhelming majority are of *coppice with standards* type. Before they ceased to be managed in the course of the twentieth century the majority of their trees and shrubs were cut down to a point at or near ground level on a regular rotation, in order to provide a continuous supply of 'poles' for fencing, tools, minor parts in buildings and a host of other purposes, as well as fuel in the form of charcoal or faggots. Regenerating coppice stools were vulnerable to grazing livestock and ancient woods are therefore usually surrounded by substantial 'woodbanks', which are accompanied by an external ditch and were originally topped by a fence, hedge or dead hedge (Rackham 1976, 70–71). Woods were lordly property, part of the manorial demesne; they were enclosed from wider areas of grazed woodland, exploited by local communities, in order to allow for the more efficient production of timber and in particular, wood. Some enclosed, coppiced woods existed before the Norman Conquest but there is general agreement that the majority of the woodland recorded by Domesday was grazed wood-pasture, and that most ancient woods originated in the period between the eleventh and the later thirteenth century (Barnes and Williamson 2015, 38–42; Rackham 1976, 58–71; Rackham 1986, 120–1). As the population grew and the area under cultivation expanded, manorial lords enclosed surviving portions of the dwindling 'wastes' and brought them into more intensive management.

The enclosure, and definition, of ancient woods thus overlapped chronologically with the formation of ecclesiastical parishes, a process which largely occurred in the period between the ninth and the twelfth centuries (Blair 2005; Winchester 2000). This said, particular lengths of parish boundary might themselves be significantly earlier, or later, in date. Where adjacent parishes were separated by an area of common land, a physical boundary between them might only come to be defined when this was enclosed in the post-medieval period. And, because parishes developed through the fission of the *parochiae* of Anglo-Saxon *mynsters*, some were bounded in part by fragments of the outer limits of these earlier and larger ecclesiastical territories (Blair 2005). To complicate matters further, the pattern of parishes mainly developed as local landowners erected churches on their own properties, to serve the spiritual needs of their families and dependents, and as a symbol of status; they endowed them with glebe from their own lands, and with the tithes formerly paid by their tenants to a local *mynster*, and the bounds of the parish accordingly fossilised those of an estate, and agricultural territory, that might already have been several centuries old (Blair 2005; Morris 1989, 227–29). Not surprisingly, the bounds of estates described in Anglo-Saxon charters often correspond with those of medieval parishes (Rackham 1986, 19). But it is also clear that parish formation did not always occur in this neat and tidy manner. In some cases two or more landowners, even groups of peasant proprietors, jointly endowed a church, the parish of which would accordingly 'ghost' the combined area of several properties (Warner 1986; Morris 1989, 230).

Any relationship between ancient woods and parish boundaries is thus, in reality, likely to be an association with the limits of early secular territories, and presumably with agricultural margins. This could be a simple consequence of the historic development of land use patterns, reflecting the fact that when in the early Middle Ages manorial lords enclosed, and began to manage, surviving fragments of woodland, these tended to be located towards the margins of agricultural territories. Alternatively, the association could be interpreted in terms of theoretical land use models, with areas most regularly used by communities, such as arable fields, lying close to the principal settlements and those less regularly exploited, such as coppice woods, lying at a distance (Roberts 1987, 20–21). Or it might be the outcome of a combination of these factors. A perhaps more basic question, however, is how frequent the association of woods and parish boundaries really is or, to put it another way, how powerful is proximity as a predictor of a wood's 'ancient' status?

Measuring Proximity

Demonstrating the strength of the suggested association in objective, statistical terms is not straightforward because geometric considerations preclude any absolute threshold values: in a small parish, a wood of a given size is more likely to lie close to the parish boundary by chance than in a larger one. As historic parishes range in size from 14 ha (Dallinghoo Wield, Suffolk) to over 410 km^2 (Whalley, Lancs.), this is a significant problem. And in a similar way larger woods are more likely than smaller woods to lie close to a parish boundary by chance. The varying shapes of woods and, in particular, parishes will complicate matters further; a wood of a given size is more likely to lie close to the boundary of a parish of a given size if the latter has an elongated, attenuated form than if it has a shape approximating more to a circle.

It is possible to address these issues in a systematic and objective manner using Geographical Information Systems (GIS) and mathematical modelling. To assess whether a given ancient wood lies closer to a parish boundary than would be expected by chance, a Monte Carlo permutation test is performed using a custom-built R script (R Core Team 2022), as shown in Figure 1. The actual distance between the wood and the parish boundary is first measured, using the *gdistance* package (van Etten 2017) ('a'). Then the wood is randomly moved within the parish ('b') using a random number generator to produce a new latitude and longitude for its centre, subject to the constraint that no part of the wood should cross the parish boundary. The minimum distance between the two is then calculated using the *rgeos* package (Bivand *et al*. 2017). This process is repeated 999 times ('c'—'g') to generate a distribution of 'chance' wood-parish boundary distances. A *p*-value is then calculated for each wood by counting the number of permuted wood-parish boundary distances which are less than or equal to the actual wood-parish

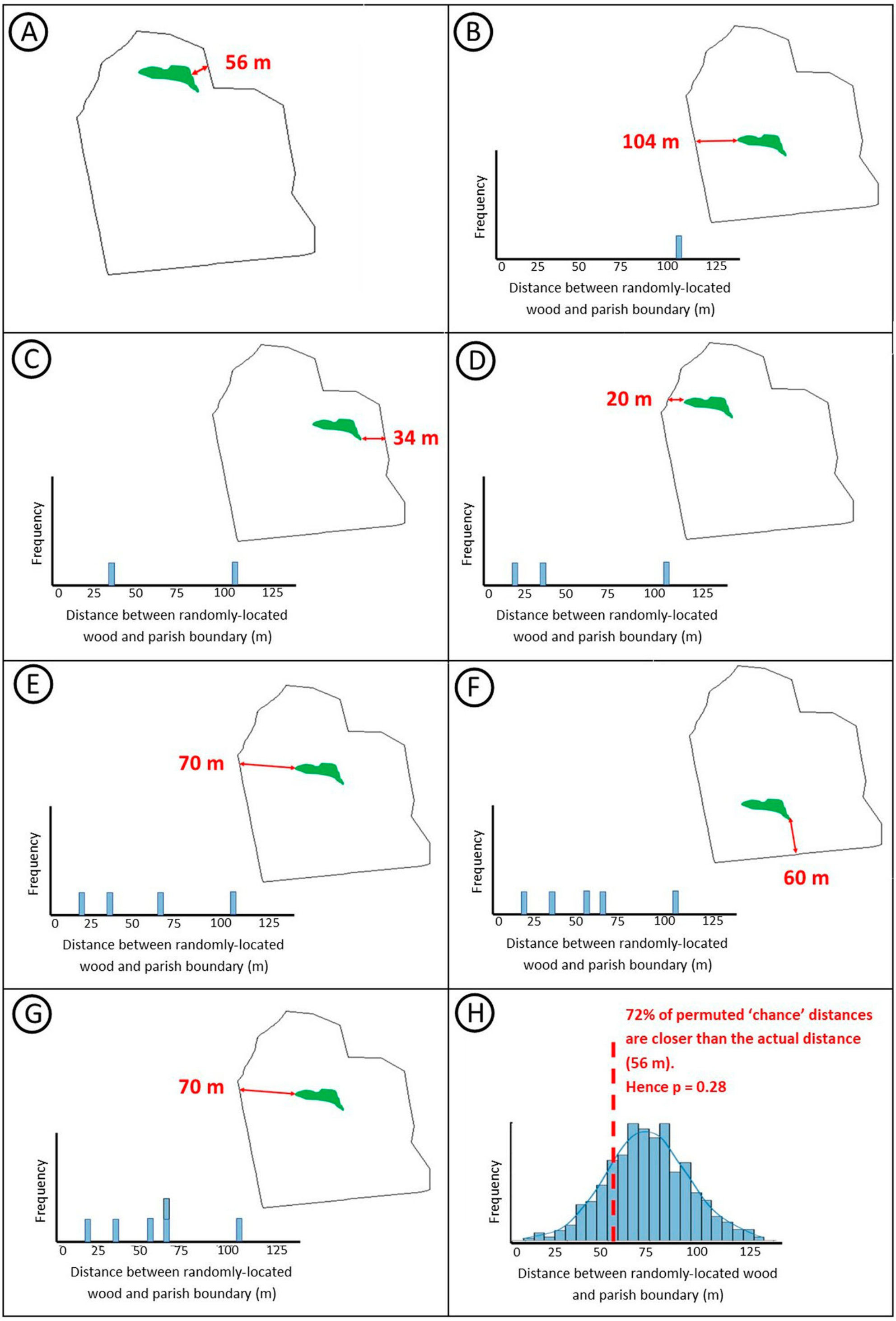

Figure 1. Calculating a *p*-value for the relationship of an individual wood to a parish boundary.

boundary distance and dividing this figure by 1000 (Figure 1 'h'). *P*-values can thus range between zero and one; the lower the value, the more significant the actual association between wood and boundary, and vice-versa. Finally, a histogram is constructed showing the *p*-values for all the woods within a sample area. If this has a left-handed peak, then a high proportion of woods have a low *p*-value, indicating a strong tendency for them to be found close to a parish boundary. Conversely, a right-handed peak means that a high proportion have a high *p*-value, signalling a significant tendency for woods to be located away from a boundary. If the histogram has no peak (i.e. is flat with all bars roughly the same height), then this means that there is no overall tendency for woods to be found particularly close to or far away from parish boundaries: the mean *p*-value in this case would be 0.5 (no association either way).

GIS shapefiles for the boundaries of all ancient woods within an area of 19,102 square kilometres in the English south-east Midlands and East Anglia—the historic counties of Bedfordshire, Cambridgeshire, Essex, Hertfordshire, Huntingdonshire, Norfolk and Suffolk—were obtained from the digitised version of the Ancient Woodland Inventory (Natural England 2022). Individual areas of ancient woodland are often made up of a number of conjoined, but historically distinct and individually named, ancient woods, often as the result of the division of demesne property in the course of the medieval and post-medieval periods. If in the digitised Inventory such woods were represented as multiple adjacent or nested polygons, these were combined into one single polygon using the *sf* and *nngeo* packages (Pebesma 2024; Dorman *et al.* 2024). Each woodland area was thus represented by a single undivided polygon which was manually verified by comparing it with the relevant late nineteenth-century Ordnance Survey map and adjusted where necessary, an approach that left us with an overall sample of 2,377 ancient woods. Satchell *et al.*'s (2016) GIS shapefile provided the parish boundaries: based on the mapping work of Kain and Oliver (2001), this dataset contains all parish boundaries in England and Wales at the time of the 1851 census. If the parish included detached parts (exclaves or enclaves not connected to the rest of the parish), then only that portion containing the focal wood was considered in the analysis.

Overall, the results reveal that there is, indeed, a clear statistical tendency for areas of ancient woodland to lie close to boundaries, even allowing for the fact that this was one of the criteria used for membership of the dataset in the first place. The histogram of *p*-values has a clear left-hand peak (Figure 2). Indeed, of the 2,377 areas of ancient woodland within the study area, over a third—35 per cent—lie in more than one parish: 28 per cent cross one parish boundary whilst 6 per cent lie in three parishes. Nineteen woods lie in four parishes and four extend into five; Box Wood (Herts.) spans eight.

Woodland and Champion

What is more interesting, however, is that there are differences between the various counties studied in the strength of the association. It is possible to discern these by eye, on the map (Figures 3–5), but they are more clearly demonstrated statistically using three different measures. When these are considered together, three groupings are apparent.

Huntingdonshire, Cambridgeshire, and Bedfordshire show the strongest relationships, with low average *p*-values (0.14, 0.22, and 0.23 respectively), short average distances from wood to parish boundary (88, 146, and 151 metres respectively), and high proportions of

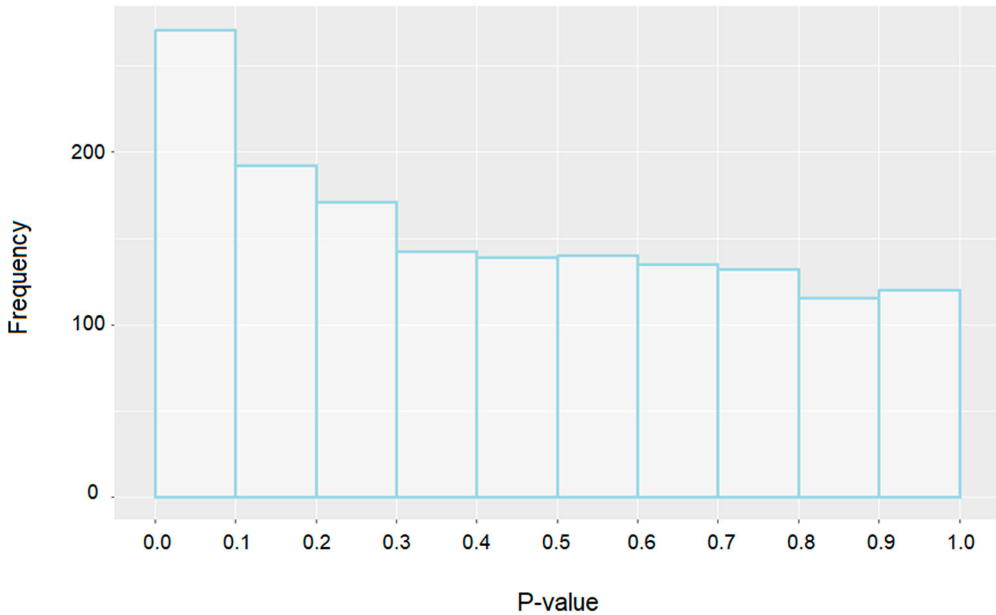

Figure 2. Histogram of aggregate *p*-values of wood/parish boundary relationships within the study area.

woods straddling boundaries (67 per cent, 42 per cent, and 38 per cent). Norfolk and Suffolk occupy an intermediate position, with average *p*-values of 0.25 and 0.28, average distances of 155 and 168 metres, and 37 per cent of woods straddling boundaries in each county. The relationship is weakest in Hertfordshire and Essex, where average *p*-values are 0.34 and 0.26, average wood—boundary distances are 291 and 188 metres, and 27 per cent and 39 per cent of woods straddle boundaries respectively. Plotting the mean distance to the parish boundary against the percentage of the county occupied by ancient woodland reveals a strong positive relationship, albeit with a small sample size (Spearman's correlation coefficient: $\rho = 0.61$ $n = 7$); that is, 37 per cent of the variance in the 'edginess' of woods is explained by the extent of the woodland surviving in the county.

The simplest interpretation is that this supports the 'clearance working outwards' model: the more woodland that has been cleared in any area, the higher the proportion of what remains will lie towards the parochial margins. Yet in many contexts in which ancient woods are abundant, as on the boulder clay plateau of Hertfordshire or Essex, there are no obvious reasons why the expansion of agricultural land should have leap-frogged so many areas of wooded ground on the way to the margins; why, that is, a low level of clearance should not simply have produced large areas of woodland, perhaps in continuous bands, along parish boundaries. It is, therefore, possible that the variations reflect more complex influences, relating to patterns of settlement and territorial organisation.

Huntingdonshire, Cambridgeshire and Bedfordshire are, for the most part, characterised by 'champion' landscapes; by the thirteenth century settlement in most parishes took the form of nucleated villages and the majority of the land was farmed as communal open

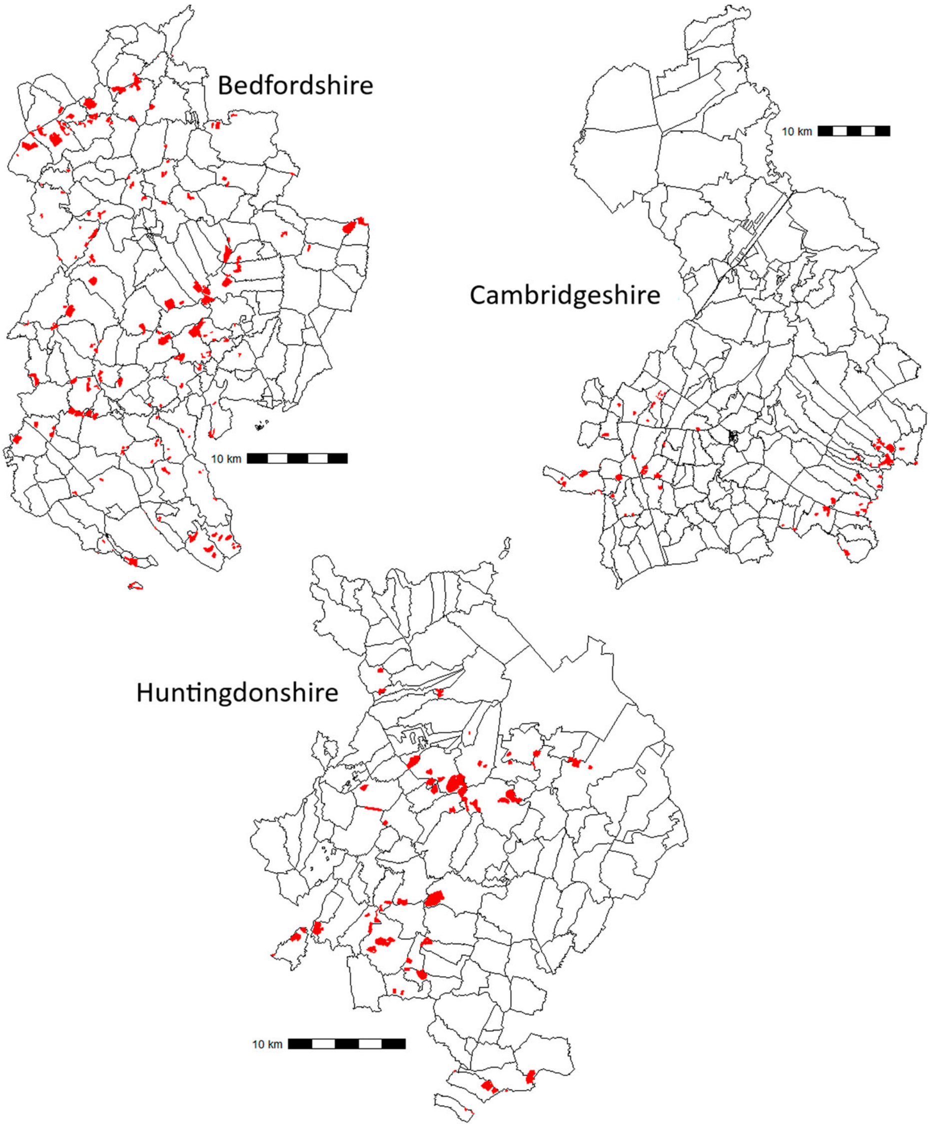

Figure 3. Ancient woods and parish boundaries in Bedfordshire, Cambridgeshire and Huntingdonshire.

fields (Roberts and Wrathmell 2000, 9, 51–4). Essex and Hertfordshire, in contrast, were —with the exception of the far north-west of both counties—classic areas of 'woodland' or 'ancient' countryside, with a mixture of enclosed field and patches of 'irregular' open fields, and a highly dispersed pattern of settlement, with each parish usually containing a number of discrete settlement foci. Norfolk and Suffolk occupy an intermediate position—extensive areas in the west of both counties have landscapes that conform more closely to the 'champion' than to the 'woodland' model. In addition, settlement within their 'woodland' areas, while dispersed, often took the form of loose, messy scatters of settlement around the margins of chains of interconnected commons, rather than featuring the kind of quite isolated manorial sites, and more focused and distinct hamlets, often

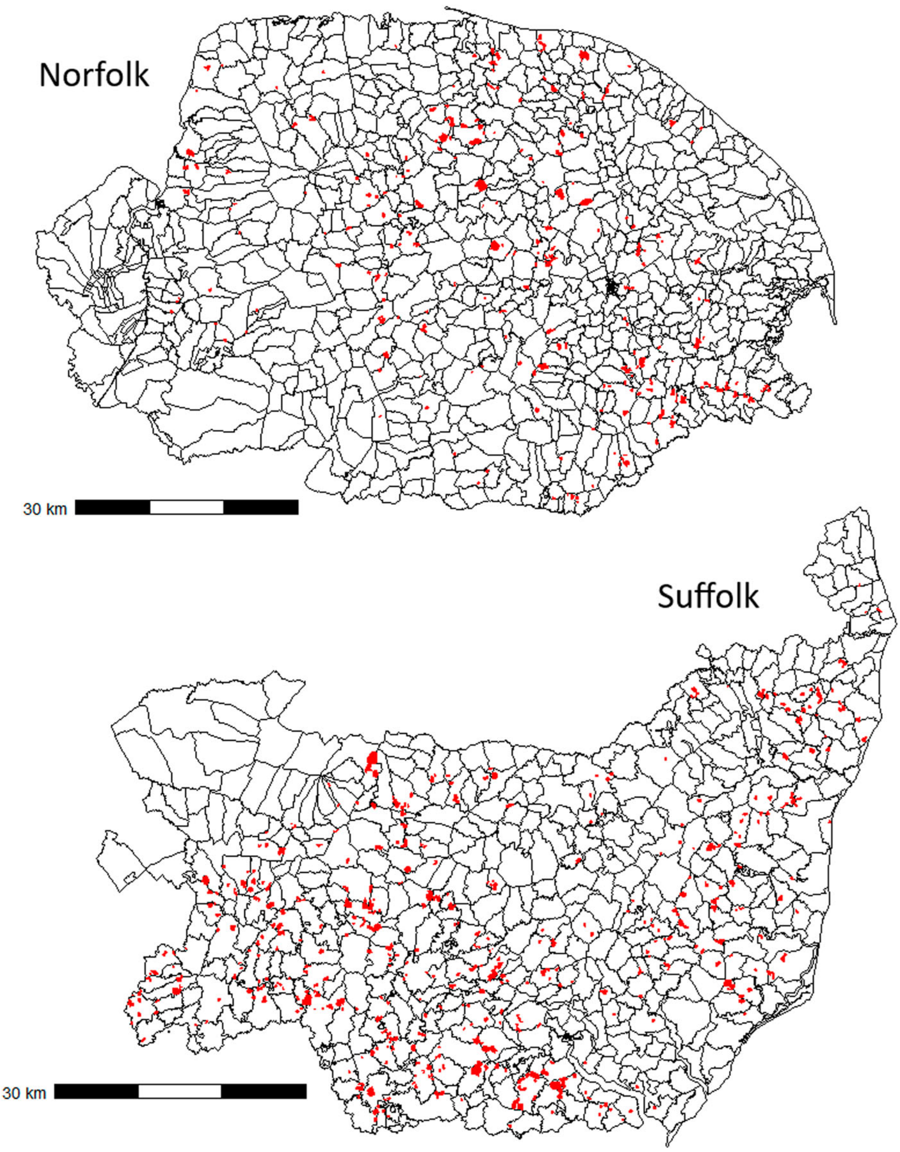

Figure 4. Ancient woods and parish boundaries in Norfolk and Suffolk.

found in Hertfordshire or Essex (Martin and Satchell 2008; Roberts and Wrathmell 2000, 151–62).

Debate has continued for decades over the reasons for these variations in settlement patterns and field systems but there is no doubt that they were already crystalising out by the time of the Norman Conquest; a significant proportion of dispersed settlements, lying at a distance from parish churches, in Hertfordshire and Essex have names featuring Old English elements, and some are associated with diminutive Domesday vills that never attained parochial status (Williamson 2013, 134, 151–4; Rowe and Williamson 2013, 66–71). It is thus possible that the less close association between ancient woods and parish

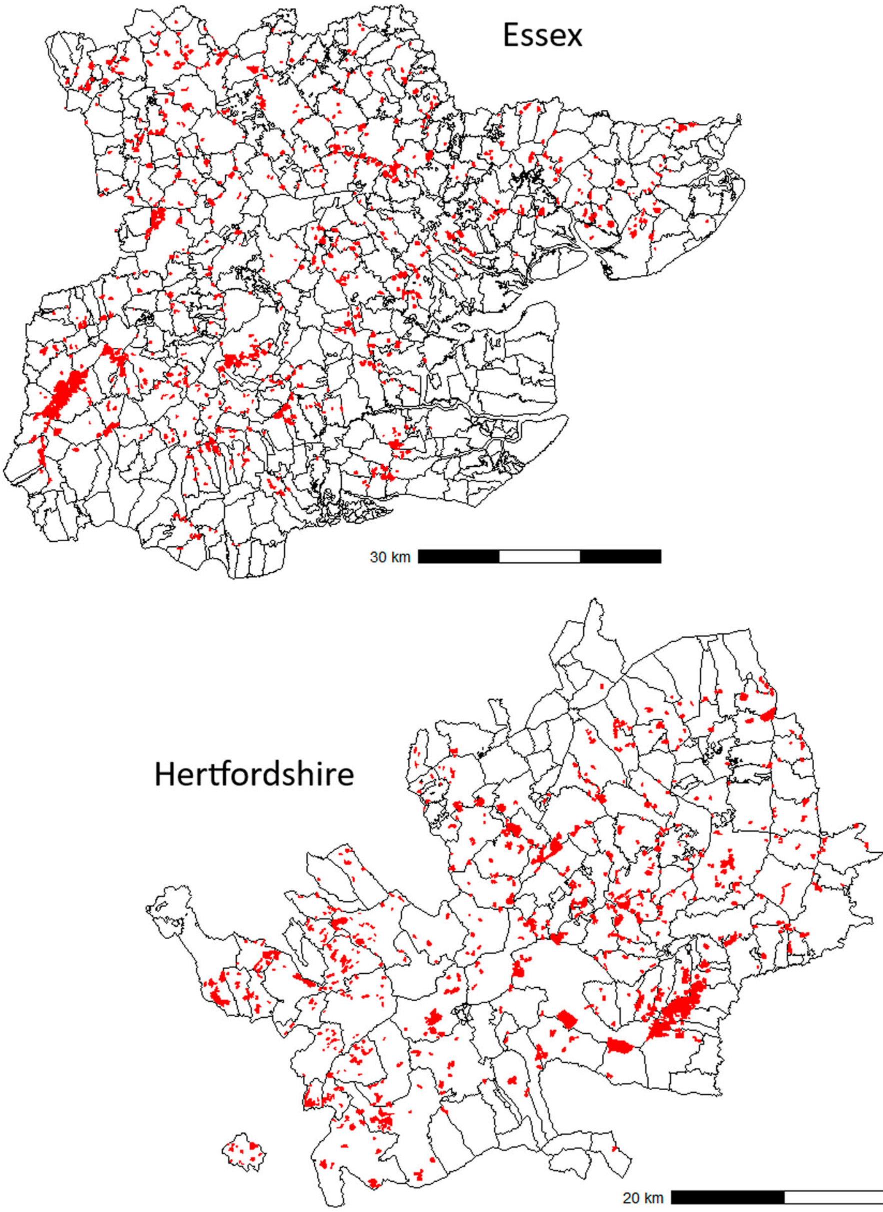

Figure 5. Ancient woods and parish boundaries in Essex and Hertfordshire.

boundaries in these counties is a consequence of the fact that each medieval parish contained a number of quite distinct early settlement foci from which clearance and settlement expanded, so that a significant proportion of ancient woodland survived on or close to the boundaries between their associated agricultural territories, rather than on the parish boundary itself.

In areas like Bedfordshire, Cambridgeshire or Huntingdonshire, in contrast, where a more nucleated pattern of settlement of discrete villages developed, clearance and cultivation proceeded from a single area and, at the point when some of the remaining areas of woodland were enclosed and brought into more intensive management, these mainly survived on the margins of larger agricultural territories. Such a model doubtless simplifies a more complex pattern of development, not least because areas of dispersed settlement in lowland England were generally more densely wooded than ‘champion’ ones, and had been at the time of Domesday when most of the woodland recorded was grazed, rather than coppiced (Roberts and Wrathmell 2000). It is possible, however, that this is also in some way related to the dispersed nature of settlement and the character of associated field systems. Certainly, the woodland densities recorded by Domesday, and the population densities, are not strongly correlated, and in later centuries many well-wooded areas of dispersed settlement were more densely populated than nearby, sparsely wooded, ‘champion’ districts (Williamson 2013, 147–61). But such speculations are less important than our principal finding. In ‘champion’ areas, where ancient woods are relatively scarce, a high proportion lie on or close to parish boundaries and such proximity is a strong indication of ‘ancient’ status. But in ‘woodland’ areas, where ancient woods are generally more abundant, many lie at a distance from parish boundaries. While woods found on or close to boundaries in both kinds of countryside have a high probability of being ‘ancient’, proximity alone will predict a lower proportion of the total population in ‘woodland’ than in ‘champion’ areas.

Ancient Woodland and Parochial ‘Nodes’

The relationship of ancient woods to parish boundaries has often been noted. What has not previously been commented on is their close association with parochial ‘nodes’, that is, the points where three (or more) parishes meet. This association is often encountered but, once again, needs to be tested objectively. We employed a similar approach to that used above to examine the relationship between woods and boundaries: that is, by calculating one-tailed *p*-values that compare the real location of each wood to 999 randomly generated ones, although this time limiting the exercise to the 65 per cent of woods that lie within a single parish (significant complications are introduced if areas of woodland straddling parish boundaries are included, as the nodes on both parishes then need to be considered). Our results show a strong tendency for woods to be found close to nodes in the parish boundary network: 35 per cent were situated significantly close to at least one node using the conventional threshold of significance ($p < 0.05$); the mean minimum node *p*-value for parishes containing ancient woods was 0.11 (SD = ± 0.11).

It might be argued that this approach is flawed because in larger parishes, with more nodes on their boundary, the minimum value will be lower ‘by chance’ and the statistical problem of multiple comparisons arises. The mean average number of nodes per parish is 7.3 (SD = ± 2.75), but some have many more and some many less. The geometrically complex parish of Writtle (Essex) has eighteen nodes on its boundary, and therefore eighteen associated *p*-values. A wood in this parish is certainly more likely by chance to have a lower minimum *p*-value than a parish with three nodes (and therefore three associated *p*-values). Implementing a meaningful multiple comparisons correction here is challenging due to the fact that a wood can only be close to a small subset (most often only one) of the total number of nodes: conventional multiple comparison corrections (e.g. Bonferroni, Sidak’s) therefore become unreasonably conservative with inflated Type II error rates. Further complications arise from the fact that the multiple tests being performed (for each node on the parish boundary) are also not independent of each other. Whilst there is a significant negative correlation between the number of nodes and the minimum p-value (Spearman's correlation test: $\rho = -0.19$, $p < 0.0001$), this only explain ~4 per cent of the variation in minimum p-values, far too small to account for the observed pattern. To bypass the problems of multiple comparisons entirely, we also reran a much more limited version of the analysis in which we tested for a significant association between the wood and the nearest node only. This produced near-identical results (mean p-value = 0.13, with 34 per cent of all woods tested having a significant p-value of <0.05). Finally, it is important to note that, because this exercise (for the reasons given above) omits all woods extending into two or more parishes, it takes no account of the large number (around 6 per cent) which actually straddle a 'node'.

Ancient woods are thus disproportionately likely to be found near nodes in the parish boundary network. The most likely reason for this is that such locations are often particularly remote from the principal settlements, and the earliest settled areas, in a parish; the kinds of 'nodes' around which ancient woods cluster are typically located on drift-covered uplands in areas in which the principal early settlement core, marked by the parish church, lies in or beside a major valley. The explanation for the observed relationship again lies in the late survival of wooded 'waste' in spatially marginal locations. What we might term 'nodal proximity' represents a particularly good predictor of a wood's 'ancient' status.

Ancient Woods and Soil Boundaries

As noted earlier, ancient woodland tends, perhaps unsurprisingly, to be found on the more agriculturally marginal soils, mainly those formed in poorly draining clays but also, to a lesser extent, in acid sands and gravels. In Rackham's words, woods are found 'not so much on sites that are good for growing trees as on sites that are bad for anything else' (Rackham 1976, 112). Within the area of eastern England studied here this tendency is particularly clear. Of the 27 broad numerical soil categories, groupings of similar 'associations', mapped by the national Soil Survey within this area, no less than 28 per cent of 'Inventory' woodland occurs on category 411, comprising the Evesham and Hanslope Associations, slowly permeable calcareous clay soils formed in chalky till (Figure 6, above) (Hodge *et al.* 1984). A further 34 per cent is found on other, more intractable clay soils, seasonally waterlogged stagnogleys, associated with glacial till or Jurassic clays: categories 711 (Beccles and Wickham Associations, 12 per cent); 712 (Denchworth and Ragdale, 15 per cent); and 714 (Oak and Essendon, 7 per cent). A further 26 per cent overlies gleyic or stagnogleyic brown earths (categories 572, 573 and 582), again clayey and poorly draining in character, while 2 per cent is associated with the acidic, freely-draining soils of the various Newport Associations (551), formed in sands and gravels.

These eight groupings account for 90 per cent of ancient woods in the area, the remaining nineteen groupings—variously free-draining loams and sands, or soils formed in peat or alluvium—making up the rest. Such raw statistics are a little misleading, however, as they take no account of the percentage of the study area covered by these various types of soil; the fact that 28 per cent of the woodland occurs on one mapped category would have no significance if it made up 28 per cent of the land area. The ratio of the

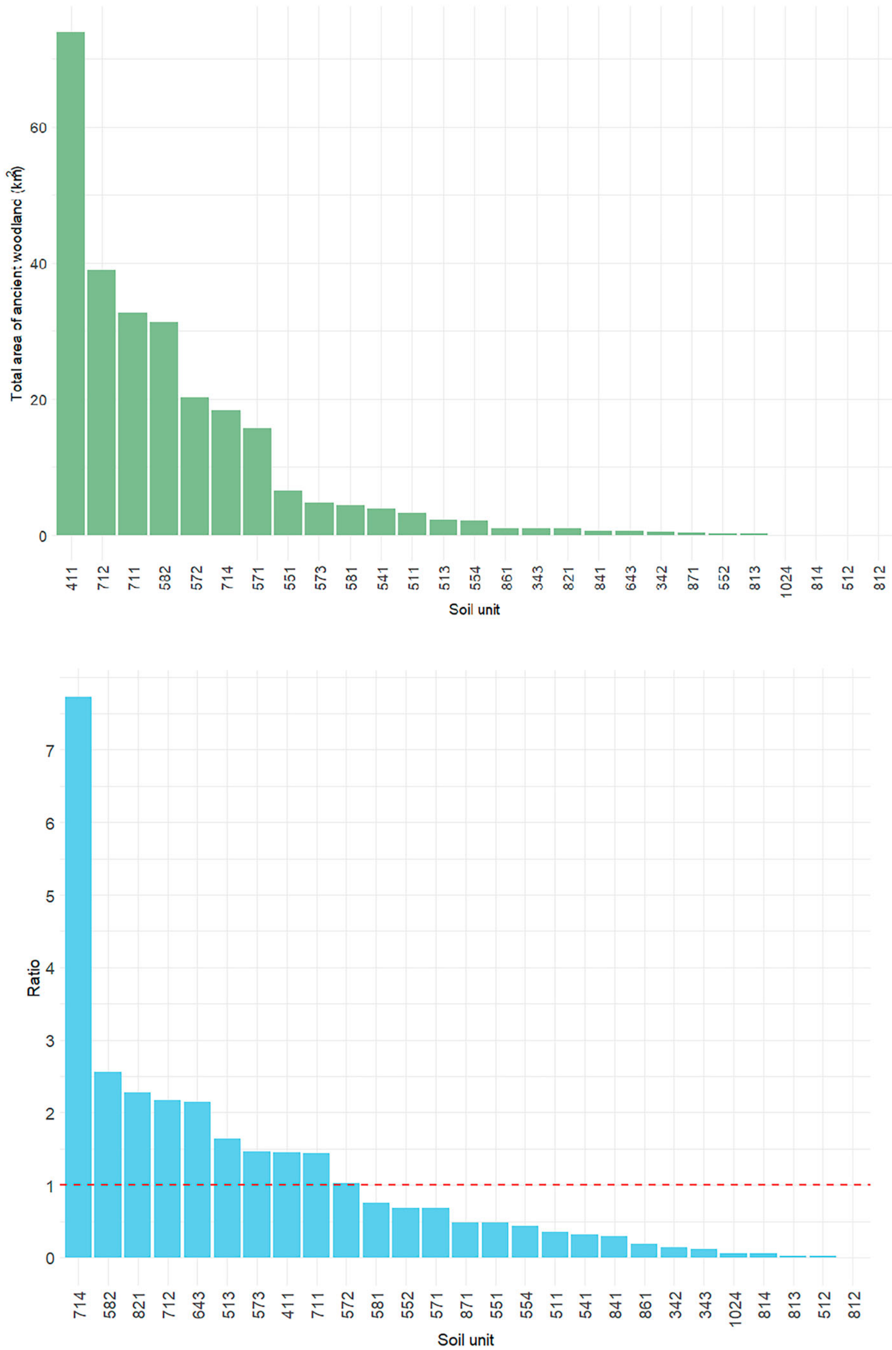

Figure 6. Above, the distribution of ancient woodland area by soil type. Below, the ratio of actual to expected area of ancient woodland across soil types (red dashed line = null expectation).

actual area of ancient woodland on each soil type to the predicted area is shown in Figure 6 (below). Soil category 714 has over seven times as much ancient woodland as expected, only making up 1 per cent of the soils in the study area; 411, 711, 712, and 582 all again score well under this measure, but cover rather greater areas of land (nearly a fifth of the total land in the study area, in the case of 411); as does 573. Two categories—511 and 571 —loose their significance and four are 'promoted'; 513, 643 and 821 all have more ancient woods than might be predicted, although all cover only small areas of ground within the study area.

From this we might argue that soil type is a useful if—with the exception of the extremely intractable 714 Oak and Essendon Association soils—relatively weak predictor of a wood's 'ancient' status. Unsurprisingly, ancient woods are principally associated with poorly draining clay soils. More remarkable, however, is the observation that a more powerful indication is provided by where ancient woods lie within the mapped areas of the relevant soil categories for, in a manner curiously analogous to their situation within parishes, woods congregate noticeably towards their boundaries. Indeed, of the 2,377 areas of ancient woodland within the study area, no less than 28 per cent straddle a mapped soil boundary. For the remaining woods, lying within a single soil category, *p*-values can be calculated using the procedure already described when examining the relationship with parish boundaries; the resulting histogram shows clearly that there are far more woods that are closer to the boundary than expected by chance (low *p*-values) than there are displaying no association with it (p close to 0.5) or located at a significant distance (high *p* values) (Figure 7). It is important to emphasise that this relationship does not reflect any tendency for parish boundaries, and mapped soil boundaries, to occur in close spatial proximity, for this rarely happens (Figure 8). Moreover, there is no significant correlation between a wood's soil boundary *p*-value and its parish boundary *p*-value (Spearman's correlation test: $\rho = 0.02$, $p = 0.46$). Proximity to parish boundaries and soil boundaries therefore have independent influences on woodland location. There is, we should also note, a statistically significant correlation between woodland size and the 'edginess' *p*-value: the larger the wood, the lower the *p*-value and hence the more likely

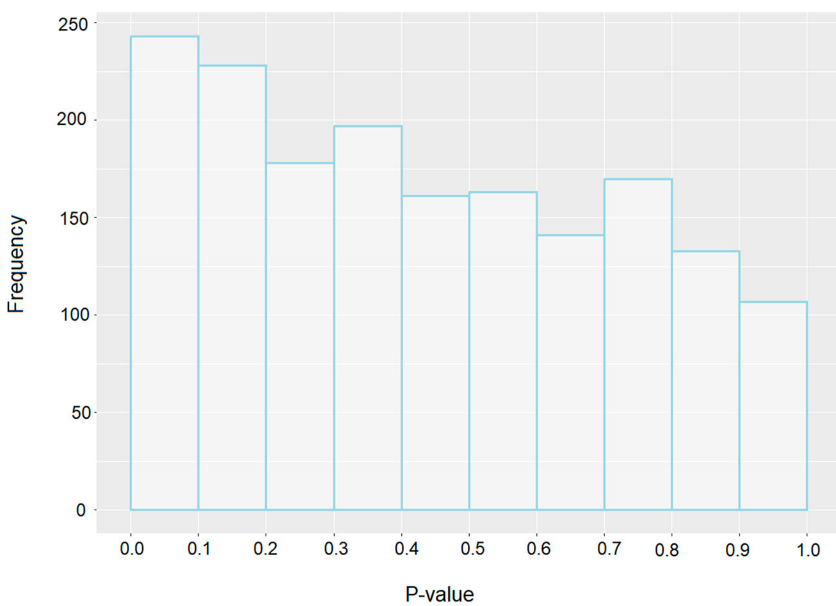

Figure 7. Histogram of aggregate p-values of wood/soil boundary relationships within the study area.

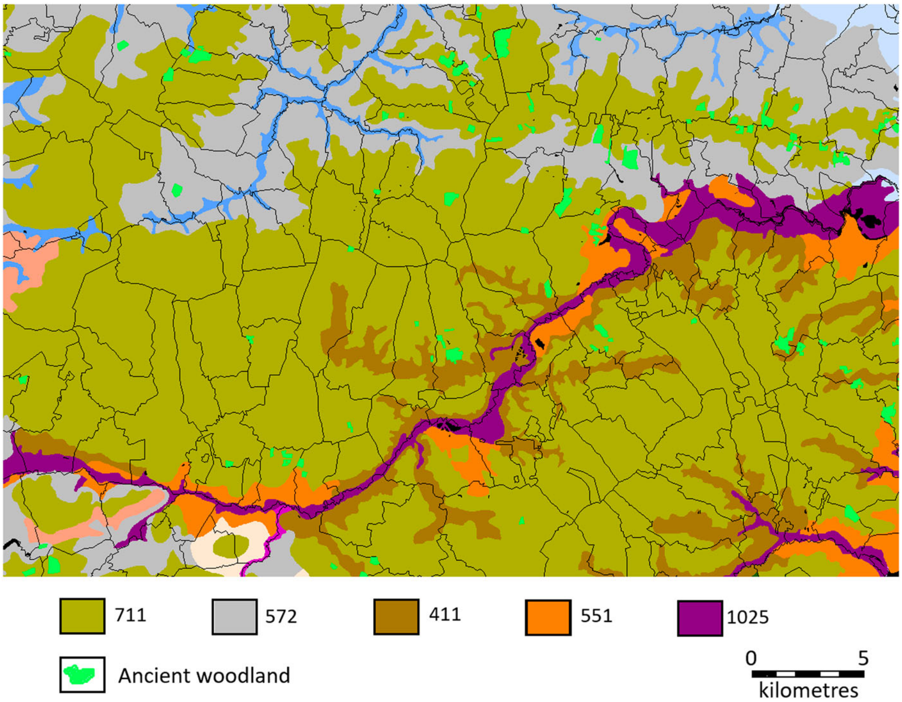

Figure 8. Ancient woods, soils and parish boundaries in south Norfolk and north Suffolk. Most ancient woods are located on the poorly-draining stagnogleys of the Beccles 2 and 3 Associations (711), which characterise the level ground of the boulder clay plateau. They are not evenly scattered, however, but cluster towards the plateau margins. They thus lie on or close to the boundaries with other soil types, found on the sides of the principal valleys; lighter, sandy clays of the Burlingham 1 and 3 Associations (572); calcareous clays of the Hanslope Association (411); or acid sands of the Newport 3 and 4 Associations (551). The band of peaty soils (Mendham Association: 1025) running from east to west is the floodplain of the river Waveney, which forms the boundary between Norfolk and Suffolk.

it is for the wood to be found close to a soil boundary (Spearman's correlation test: $\rho = -0.11$, $p < 0.0001$). However, this explains very little of the variation in how 'edgy' a wood is (~ 1 per cent).

The association of ancient woods and the boundaries of soil types has never previously been demonstrated statistically. But it has been described more subjectively in the past, by Warner on the boulder clays of Suffolk (Warner 1987, 5–9); by implication, by Witney in the Weald of Kent (Witney 1998, 20–21); as well as in Norfolk and Hertfordshire (Barnes and Williamson 2015, 43–5; Rowe and Williamson 2013, 75, 127–9) (Figure 8). Across much of the area studied here the relationship has a strong topographic aspect, for the principal clay soils are formed in glacial till which caps relatively level plateaux. The soils occupying adjacent valley sides or escarpments, in contrast, tend to be freely-draining either because they are formed in some older permeable formation such as chalk or in clay formations which, lying on a slope, tend to shed water more easily than on the plateaux above. The consequent concentration of woodland on the edge of the uplands can have a major impact on the experience of the landscape, especially in eastern Hertfordshire and northwest Essex. Viewed from the valley floors, where the largest settlements tend to be found and along which the main

Figure 9. The Rib valley in east Hertfordshire. Woodland clusters at the top of the valley slopes, making the higher ground appear more densely wooded than it really is. (Anne Rowe)

roads and rail lines generally run, the higher ground appears much more densely wooded than it really is (Figure 9).

Witney observed how, by late medieval times, most woodland within the Weald of Kent and Sussex survived towards its outer edges rather than, as we might expect, towards its centre, and explained this pattern largely in terms of access. Areas of woodland came to be enclosed, and more intensively managed, in places where their produce could be transported to markets with relative ease. Moving wood and timber from the 'central core of the Weald' in contrast, along unsurfaced clay roads, was virtually impossible for much of the year. Colonisation in the period between the eleventh and fourteenth centuries was thus directed by manorial lords into the more remote districts, where woodland was converted to farmland, or else degenerated to open common (Witney 1998, 20). Such a model works well, albeit at a different scale, in the areas studied here, although often with the additional factor of topography. The light soils of the valleys were settled earlier than the clay uplands and the most important manorial sites tended to be located here, while the principal transports generally followed these ribbons of lower ground. Woods preserved on the plateau margins were conveniently located in relation to both.

Conclusion

It might be thought that these two determining influences on the location of ancient woodland—proximity to a parish boundary, and marginality within areas of difficult clay soils—are contradictory, the one suggesting the importance of remoteness, the other that of accessibility. But, given the complexity of both the natural topography, and the parochial network, there are usually abundant opportunities for ancient woods to fulfil both locational criteria, typically occurring close to where parish boundaries running up the sides of valleys meet heavier soils on higher ground. Such patterns are not always so visually obvious as they are in Figure 8, however, and in more general terms the kinds of GIS approaches briefly outlined here can serve to highlight relationships and associations in the historic environment that are not immediately apparent, as well as test the significance of those that are. They deserve to be more widely employed in studies of the English rural landscape.

Disclosure Statement

No potential conflict of interest was reported by the author(s).

Notes on Contributors

Andrew Catherall-Ostler read Natural Sciences at Homerton College, Cambridge (2015-2018) and then completed a PhD in evolutionary biology at Christ's College (2018-2022). His doctoral research looked at how different populations can adapt to different environmental conditions despite ongoing gene flow. He is currently College Lecturer (Assistant Professor) at Homerton teaching evolutionary biology to second and third-year students as part of the Natural Sciences Tripos. email: amc228@cam.ac.uk

Tom Williamson is Emeritus Professor of Landscape History at the University of East Anglia. He has published extensively on landscape archaeology, historical ecology and the history of landscape design. email: T.Williamson@uea.ac.uk

References

Barnes, G. and Williamson, T. 2015. *Re-Thinking Ancient Woodland: The Archaeology and History of Woods in Norfolk*, University of Hertfordshire Press.

Blair, J. 2005. *The Church in Anglo-Saxon Society*, Oxford University Press.

Bivand, R., Rundel, C., Pebesma, E., Stuetz, R., Hufthammer, K. O. and Bivand, M. R. 2017. Package 'rgeos'. *The Comprehensive R Archive Network (CRAN)*. https://citeseerx.ist.psu.edu/document?repid = rep1&type = pdf&doi = 175bda8f050204f8ccc2b0edd202476a564a84fe.

Dorman, M., Rush, J., Hough, I., Russel, D., Ranghetti, L., Benini, A., Tarroux, A., Matas, F. and Distance, C. F. F. K. 2024. *nngeo: K-Nearest Neighbor Join for Spatial Data* (Version 0.4.8) [Computer software]. https://cran.r-project.org/web/packages/nngeo/index.html.

Franklin, J. 2010. *Mapping Species Distributions: Spatial Inference and Prediction*, Cambridge University Press.

Kain, R. J. and Oliver, R. R. 2001. *The Historic Parishes of England and Wales: An Electronic Map of Boundaries Before 1850 with a Gazetteer and Metadata*. History Data Service, UK Data Archive. https://www.academia.edu/download/88100340/542.pdf.

Hodge, C. A. H., Burton, R. G. O., Corbett, W. M., Evans, R. and Searle, R. S. 1984. *Soils and their Use in Eastern England*, Soil Survey of England and Wales.

Martin, E. and Satchell, M. 2008. *Wheare Most Inclosures be. East Anglian Fields, History, Morphology and Management*, *Anglian Archaeology* 124, Ipswich.

Morris, R. 1989. *Churches in the Landscape*, Dent.

Natural England 2022. *Ancient Woodland Inventory (England)*. https://magic.defra.gov.uk/home.htm (accessed 18/5/2025).

Nolan, V., Reader, T., Gilbert, F. and Atkinson, N. 2021. Historical Maps Confirm the Accuracy of Zero-Inflated Model Predictions of Ancient Tree Abundance in English Wood-Pastures. *Journal of Applied Ecology* 58 (11), 2661–2672. doi:10.1111/1365-2664.13996.

Pebesma, E., Bivand, R., Racine, E., Sumner, M., Cook, I., Keitt, T., Lovelace, R., Wickham, H., Ooms, J., Müller, K., Pedersen, T. L., Baston, D. and Dunnington, D. 2024. *sf: Simple Features for R* (Version 1.0-19) [Computer software]. https://cran.r-project.org/web/packages/sf/index.html.

Peterken, G. 1981. *Woodland Conservation and Management*, Chapman.

Rackham, O. 1976. *Trees and Woodland in the British Landscape*, Dent.

Rackham, O. 1980. *Ancient Woodland: Its History, Vegetation and Uses in England*, Edward Arnold.

Rackham, O. 1986. *The History of the Countryside*, Dent.

R Core Team. 2022. *R: A Language and Environment for Statistical Computing*, R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/.

Roberts, B. 1987. *Rural Settlement in Britain*, Dawson.

Roberts, B. and Wrathmell, S. 2000. *Region and Place: A Study off English Rural Settlement*, English Heritage.

Rowe, A. and Williamson, T. 2013. *Hertfordshire: a landscape history*, Uniersity of Hertfordshire Press.

Satchell, A. E. M., Kitson, P. K., Newton, G. H., Shaw-Taylor, L. and Wrigley, E. A. 2016. 1851 *England and Wales Census Parishes, Townships and Places*. https://reshare.ukdataservice.ac.uk/id/eprint/852232.

Spencer, J. and Kirby, K. 1992. An Inventory of Ancient Woodland for England and Wales. *Biological Conservation* 62, 77–93.

van Etten, J. 2017. R Package gdistance: Distances and Routes on Geographical Grids, *Journal of Statistical Software*, 76 (13): 1–21. https://doi.org/10.18637/jss.v076.i13.

Verhagen, P. 2007. *Case Studies in Archaeological Predictive Modelling*, Leiden University Archaeological Studies 14.

Verhagen, P. and Whitley, T. G. 2020. Predictive Spatial Modelling. In: M. Gillings, P. Hacıgüzeller and G. Lock, eds. *Archaeological Spatial Analysis: A Methodological Guide*, Routledge, 231–246.

Warner, P. 1986. Shared Churchyards, Freemen Church Builders and the Development of Parishes in Eleventh-Century East Anglia. *Landscape History* 8, 39–52.

Warner, P. 1987. *Greens, Commons and Clayland Colonization*, Leicester University Press.

Winchester, A. 2000. *Discovering Parish Boundaries*, Shire.

Williamson, T. 2013. *Environment, Society and Landscape in Early Medieval England: Time and Topography*, Boydell.

Witney, K. P. 1998. The Woodland Economy of Kent, 1066-1348. *Agricultural History Review* 38, 20–39.

Żmihorski, M., Kowalski, M., Cichocki, J., Rubacha, S., Kotowska, D., Krupiński, D., Rosin, Z. M., Šálek, M. and Pärt, T. 2020. The Use of Socio-Economy In Species Distribution Modelling: Features Of Rural Societies Improve Predictions of Barn Owl Occurrence. *The Science of the Total Environment* 741, 1–9. doi:10.1016/j.scitotenv.2020.140407 (accessed at 18/5/2025).