SNOWDONIA'S EARLY FIELDSCAPES

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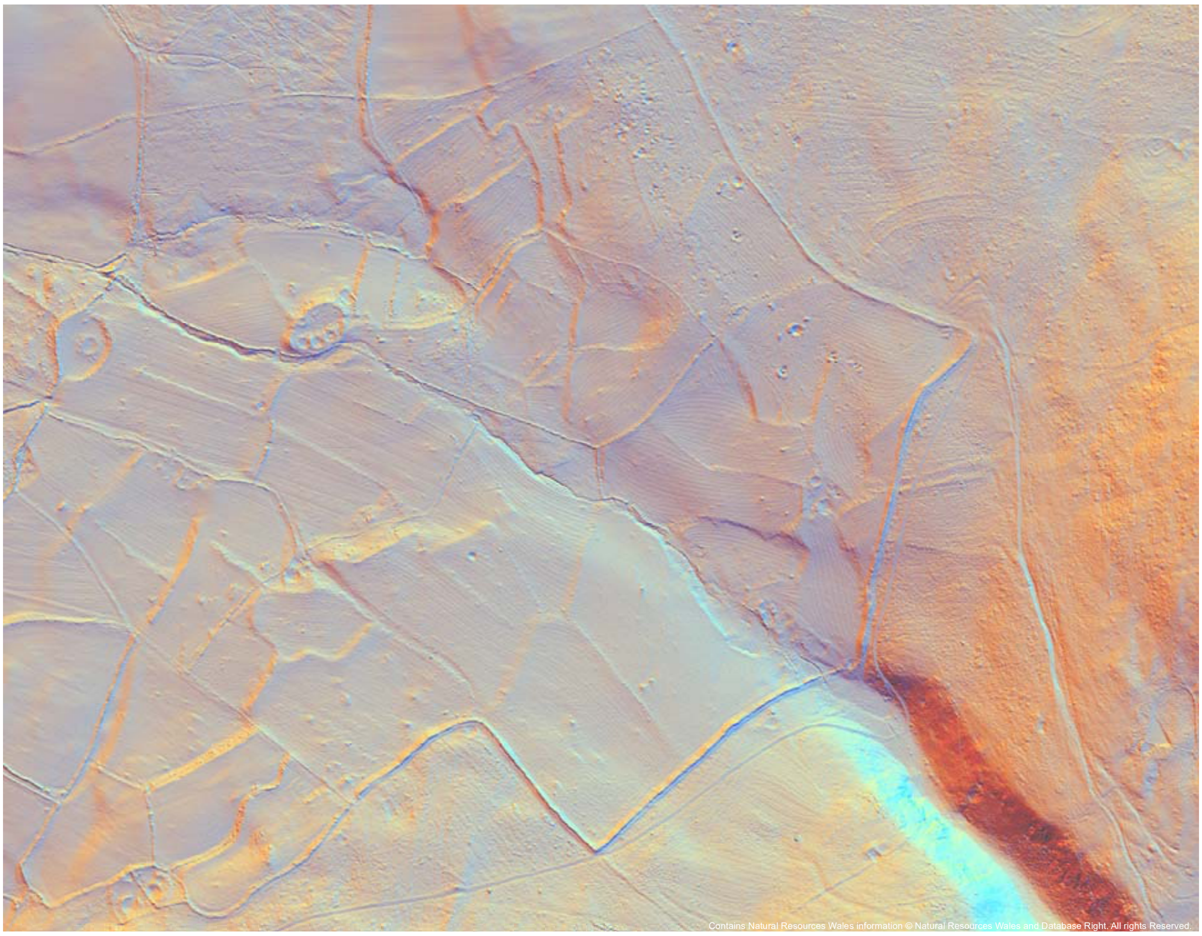

Llanllechid, Gwynedd: 0.25m resolution multi-hillshade lidar model

Abstract

Traces of stone and earthwork field boundaries, roundhouses and enclosures survive across extensive upland areas of northwest Wales. Collectively described as fieldscapes, they are among the best preserved and most complex examples of early land division in Europe. This thesis explores the human and environmental processes that led to their creation and survival between the first millennium BC and first millennium AD. It builds on relational approaches to land tenure, and considers the emergence of early land division as a long-term phenomenon.

The research is based on mapping from detailed topographic models created using existing airborne laser scanning (lidar) datasets. Archaeological remains that are difficult or impossible to observe on the ground were identified through analysis of these digital models, significantly increasing the number and geographic distribution of recorded features. The large sample size, rich metadata and consistency of the dataset provided a unique opportunity to develop new approaches to help analyse and understand these early fieldscapes. Innovative geospatial and geostatistical methods were developed to assess their cohesion, preservation and character.

The results revealed new and distinctive patterns of enclosure bound up with detailed knowledge of and responses to the region's varied landscape and local microtopography. People selected sunnier slopes to settle and farm, and they built low earthwork and stone banks to reduce the impact of prevailing winds. Across the mountainous terrain of Snowdonia, this created a network of curvilinear and irregular boundaries. On lower-lying slopes and flatter land, sinuosity was less pronounced, but boundary alignment appears to have responded to environmental conditions in a similar way. The importance of aspect and exposure suggests that further research should focus on exploring these characteristics and their relationship to the development of mixed farming practices.

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Abbreviations

ADS	Archaeology Data Service
AHRC	Arts and Humanities Research Council
AI	Artificial intelligence
ALS	Airborne laser scanning
ALSF	Aggregate Levy Sustainability Fund
ASCII	American Standard Code for Information Interchange
BSI	British Standards Institution
CDA	Collaborative Doctoral Award
DEM	Digital Elevation Model
DL	Deep learning
DSLR	Digital single lens reflex
DSM	Digital surface model
DTM	Digital terrain model
EH	English Heritage
EU	European Union
FMW	Field Monument Warden
FISH	Forum on Information Standards in Heritage
HER	Historic Environment Record
HE	Historic England
HLA	Historic Land-use Assessment
GAT	Gwynedd Archaeological Trust
GIS	Geographical Information System
NMP	National Mapping Programme
NMR	National Monument Record, maintained by RCAHMW
NNI	Nearest Neighbour Index
NPRN	National Primary Record Number, refers to records held in the NMR
OSL	Optically Stimulated Luminescence
OSL-PD	Optically Stimulated Luminescence Profiling and Dating
OxCal	Oxford Calibration
PRN	Primary Record Number, refers to records held in the HER
PPG	Planning Policy Guidance
RCAHMW	Royal Commission on the Ancient and Historical Monuments of Wales

RCZAS	Rapid Coastal Zone Assessment survey
RFH	Relative Feature Height
RVT	Relief Visualisation Toolbox
CAP SPS	Common Agricultural Policy Single Payment Scheme
SLRM	Simple local relief model
SVF	Sky-view factor
SMR	Sites and Monuments Record
SM	Scheduled Monument
SNPA	Snowdonia National Park Authority
SSSI	Site of Special Scientific Interest
TL	Thermoluminescence dating
UAO	Uplands Archaeology Initiative
WAT	Welsh Archaeological Trust

Preface

This research was undertaken through an Arts and Humanities Research Council (AHRC) Collaborative Doctoral Award (CDA) between the Snowdonia National Park Authority (SNPA) and the University of Sheffield, Department of Archaeology. It was supervised by Robert Johnston.

Genesis

The thesis is rooted in a friendship between Robert (Bob) Johnston (the University of Sheffield) and John Griffith Roberts (the Snowdonia National Park Authority). They have collaborated on different archaeological projects for almost two decades, and their knowledge and interest in the upland landscapes of Snowdonia led to the original research proposal and successful application for an AHRC CDA to fund a PhD studentship. In 2016 I was fortunate to be awarded the grant. My hope is that this study will contribute to their continued dialogue and many more years of productive and enjoyable collaboration.

Acknowledgements

I am very grateful to the Snowdonia National Park Authority (SNPA) for supporting the CDA through match-funding and in-kind support from their staff, in particular the Director of Planning, Jonathan Cawley, the Head of Cultural Heritage, Gwilym Hughes Jones (until his retirement in 2018), and the SNPA Archaeologist, John Griffith Roberts. Without John's knowledge and passion for the archaeology and mountains of Snowdonia this research would not have been possible.

I would like to thank Kate Waddington (Bangor University) for her early advice on the project and complete confidence it would all work out fine! A former colleague, Nina Steele, has been incredibly helpful, supplying downloaded data from the regional Historic Environment Record (HER) and access to the live online record. I would like to thank Angharad Stockwell, another former colleague, whose dedication accessioning grey literature reports to the HER made an enormous difference to my research, saving huge amounts of time. Other vital sources of information include original copies of upland survey data, located by staff in the archive department at the Royal Commission on the Ancient and Historical Monuments of Wales (RCAHMW) and advance copies of unpublished articles provided by George Smith. Stuart Fry kindly lent me a copy of his unpublished MA dissertation on dry stone walls.

My placement with the RCAHMW in the spring of 2017 was an enjoyable and rewarding experience; many thanks to Jon Dollery, Toby Driver, Sue Fielding, Charles Green, Daniel Hunt, Tom Pert, Nicola Roberts and Richard Suggett for being so kind and welcoming. Special thanks to Louise Barker for accommodating me for a week of my stay.

I spent a second, very productive month in Aberystwyth during the summer of 2019 at the Department of Geography and Earth Sciences. I would like to thank Sarah Davies for taking time out from her role as head of a large and very busy department to discuss the value of archaeological research to landscape ecology and of historical ecology to landscape archaeology.

Many thanks to Anwen Cooper and Chris Gosden who generously shared draft text and figures from their forthcoming book *English Landscapes and Identities* (Gosden et al. In Press-a), and their colleague, Chris Green, who also kindly sent spreadsheets and unpublished method papers, along with helpful guidance on their use. Rebecca Bennett (PTS Consultancy) provided timely advice on processing lidar models.

In my final year writing up, the thesis took an unexpected and productive turn towards more sophisticated use of GIS, following Bob's suggestion to contact Stephen Hincks, a colleague based in the Department of Urban Studies and Planning, University of Sheffield. We managed to meet in a person a couple of times before Covid-19 restricted face to face meetings. He spent many hours over the following months collaborating via email and phone to help develop new analytical approaches that were suitable for the early fieldscapes dataset. Stephen – your enthusiasm, jokes and creativity kept me sane during those potentially difficult months – thank you!

I offer heartfelt and massive thanks to my supervisor Bob Johnston who has been unfailingly supportive over the last four years, providing incisive guidance for the first time in my academic career. It made an enormous difference to the quality of the research and my experience as a PhD student. Also huge thanks to Anna and Florrie for making my trips to Sheffield so much fun!

My wider family have been an incredible and principled source of support – thank you mum and dad, Richard J, Alice LTW and Will LTB, Dewi R and the late Sheila R.

Finally, I dedicate this thesis to John, Cai, Wil and Esme, my family, whose puns, excellent cooking, table tennis skills and company during field work and visits to the mountains, ensured that I stayed motivated and happy throughout my years obsessing over lidar images and earthwork banks.

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Chapter 1
Introduction

Early fieldscapes

Look at the image above (page 2) and you will immediately notice a group of small round cells set within a larger oval enclosure. A single cell and second enclosure lie to the west. Radiating out from these features are a network of irregular ridges and hollows, scattered small mounds, dimples and areas with parallel incised lines. This is a detailed land surface model of a small upland area in Llanllechid, Gwynedd, within the Snowdonia National Park. It was created using airborne lidar, a survey method that uses pulsed laser light to measure distances between a plane-mounted sensor and the ground surface.

Compare the image with the photograph of the same area, below, and you can see that the lidar model reveals features that are difficult or impossible to detect on the ground. The technique is particularly useful for identifying extensive linear earthworks and stone wall-footings, even where they survive as very subtle remains. The features in Llanllechid are relics of ploughed out boundaries and enclosures, the foundations of roundhouses and small cairns (stone piles), collectively described in this thesis as early fieldscapes. They are part of an extensive pattern of land division found across the uplands of Snowdonia that began more than two thousand years ago.

Llanllechid, Gwynedd: photograph looking north-west

The fieldscapes of Snowdonia are among the best preserved and most complex examples of early land enclosure in Europe, but they have not been subject to sustained academic investigation for over fifty years. Previous survey and excavation, predominantly focused on settlement sites, has suggested that they date to the first millennium BC. Fieldwork and limited transcription from aerial photographs have indicated fragmentary survival across extensive areas where later agriculture has had less impact. In the last decade, however, preliminary examination of publicly available lidar datasets has revealed the survival of boundaries, enclosures and settlements across much larger areas than previously recognised. It has highlighted the potential to identify their full extent, character and cohesion.

This thesis aims to understand the processes that led to the creation and survival of early fieldscapes in northwest Wales. It brings together newly identified features visible on lidar models with existing survey and excavation results. It seeks to address the following questions:

1. What human and environmental processes explain the geographical distribution and preservation of early fieldscapes?
2. What does the form and cohesion of fieldscapes reveal about the organisation and temporality of enclosure?
3. How can spatial data structures and geostatistical methods be refined in support of analysing and understanding early fieldscapes?

The research provides an opportunity to critically examine how language and concepts are woven into data collection strategies, structures and interpretations, and how our understanding of early land enclosure is influenced by them.

Making connections between people and places millennia ago is difficult without falling back on assumptions that are based on the way we relate to land and food production in the modern world: land enclosure is linked to ownership; settlement and farming invoke permanence; the concept of economic viability and ideas of marginality influence explanations of change. These perspectives are underpinned by less benign narratives 'hidden in plain view' (Olusoga 2019) rooted in deeper traditions of modern, Western thinking. There is a tendency to think of the Roman Empire as a precursor of the British Empire (Moss 2018) and to contrast its physical remains with the huts, 'chiefdoms' and territories of 'native' populations that appear in conventional accounts of late prehistoric Wales. In the popular imagination change is often understood either explicitly or implicitly, as a shift from barbarism to civilisation (Bonacchi et al. 2016). The archaeological remains of pre-literate communities are characterised as representing both primitive and authentic indigenous people.

These ideas are part of wider philosophical approaches that draw a distinction between subject and object, creating an objectified 'other' that can be mapped, measured, explored, and exploited to the advantage of a dominant social group (Brück and Fontijn 2013). While this 'advantage' cannot be compared to oppressive and violent colonial and post-colonial contexts, these ideas about the past and the use of language have helped to frame debates about land and power, and their relationship to the character and development of human societies. The effect has been a long-lasting intellectual myopia, a lack of curiosity about early land division and the creation of boundaries, and the way that 'people use different material structures from their surroundings to imagine and think with' (Løvschal 2014a: 728).

Thesis structure

The significance and impact of these complex legacies are explored in the opening chapters of the thesis, in particular their influence on the way in which the enclosure of Snowdonia's uplands has been implicitly understood (framed) in previous narratives. The historiography of Snowdonia's early fieldscapes (chapter 2) highlights several related themes and areas of enquiry that stem from the dominance of typological studies of settlements and the influence of culture-historical models on excavation and survey strategies. Chapter 3 outlines the wider research context, tracing the development of early fields as an academic sub-discipline in northwest Europe. The breadth and variety of research provides many useful comparative studies. This body of work is critically assessed to identify themes and approaches that are most relevant to the interpretation of fieldscapes in northwest Wales.

These epistemic insights inform the second part of the thesis (chapters 4-6) which is focused on addressing how spatial data structures and geostatistical methods can be refined to support the analysis and understanding of early fieldscapes. Chapter 4 presents the data collection methods the techniques used to identify and transcribe features from lidar visualisations; the way in which features are recorded; and how the process of transcribing features is recorded to facilitate data re-use. The early fieldscapes geodatabase comprises two separate spatial datasets to help with geospatial analysis: a larger, more detailed dataset for transcribed features and a related dataset for categorised monuments. The workflows for their creation are also described, including the generation of lidar models using the Relief Visualisation Toolbox (RVT); digitisation criteria; fieldwork; categorisation criteria; and data cleansing.

The transcription results are summarised using descriptive statistics (chapter 5) and analytical statistics (chapter 6). The descriptive summary provides a broad overview of the transcription process; it evaluates the use of the RVT and discusses the geographic distribution of features and monuments, the majority of which are newly identified. Chapter 6 describes several methods developed to assess feature preservation, coherence and character. These include innovative approaches to estimate the relative height of features (RFH), grouping analysis to assess clustering and proximity of early fieldscape monument types, and methods for measuring boundary alignment, aspect and field shape. It discusses the results and their implications for understanding the organisation and temporality of enclosure.

The final part of the thesis (chapters 7-8) builds on these quantitative results to consider what human and environmental processes explain the geographical distribution and preservation of early fieldscapes. It integrates qualitative approaches with the quantitative results. Combining site-based information and previous research addresses gaps in the quantitative analysis and places the study within its wider regional setting. Excavation, survey and palaeoenvironmental evidence are all considered in detail. Broadening the interpretation allows greater scope to discuss the relationships between enclosure and settlement (chapter 7), and between subsistence and land tenure (chapter 8).

Directions for future research are identified in the concluding chapter, along with a discussion of methodological recommendations and suggestions for specific case studies.

Some brief observations about the threats to fieldscape features and the implications of the new findings on their conservation are also included in the final chapter: there is huge uncertainty about the future of food production and land management in upland Wales, and it is not clear how farm subsidy payments will be affected by the departure of the United Kingdom from the European Union. This research provides a robust and detailed evidence baseline that will help to inform debates about the future of Snowdonia's uplands, including the management of the remarkable and extensive archaeological remains for early enclosure.

Study area

Known as *Eryri* in Welsh, Snowdonia is a mountainous region of northwest Wales situated on the west coast of Britain. The English name derives from Snowdon, the highest mountain in Wales (1,085m), and until the designation of the National Park in 1951 it referred to a smaller area centred on the Snowdon massif. These uplands formed the core of the initial study area, which was expanded to encompass the northern and western areas of the Snowdonia National Park and lower lying slopes on its coastal fringes, as shown in *Figure 1.2*. The study area and Snowdonia's natural environment are discussed in more detail in chapters 5 and 6.

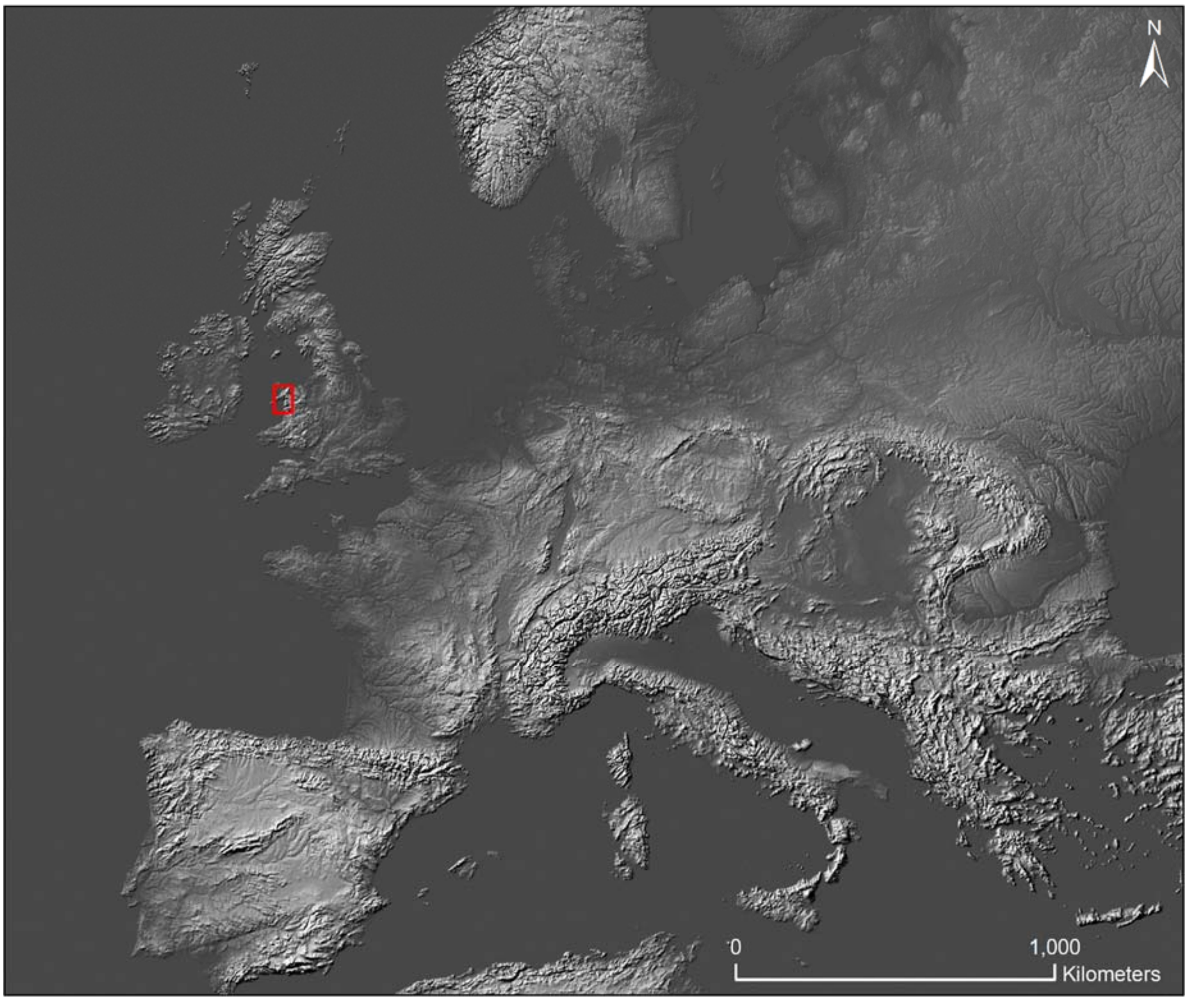

Figure 1.1
Map showing location of study area in Europe

Made with Natural Earth. Free vector and raster map data @ naturalearthdata.com

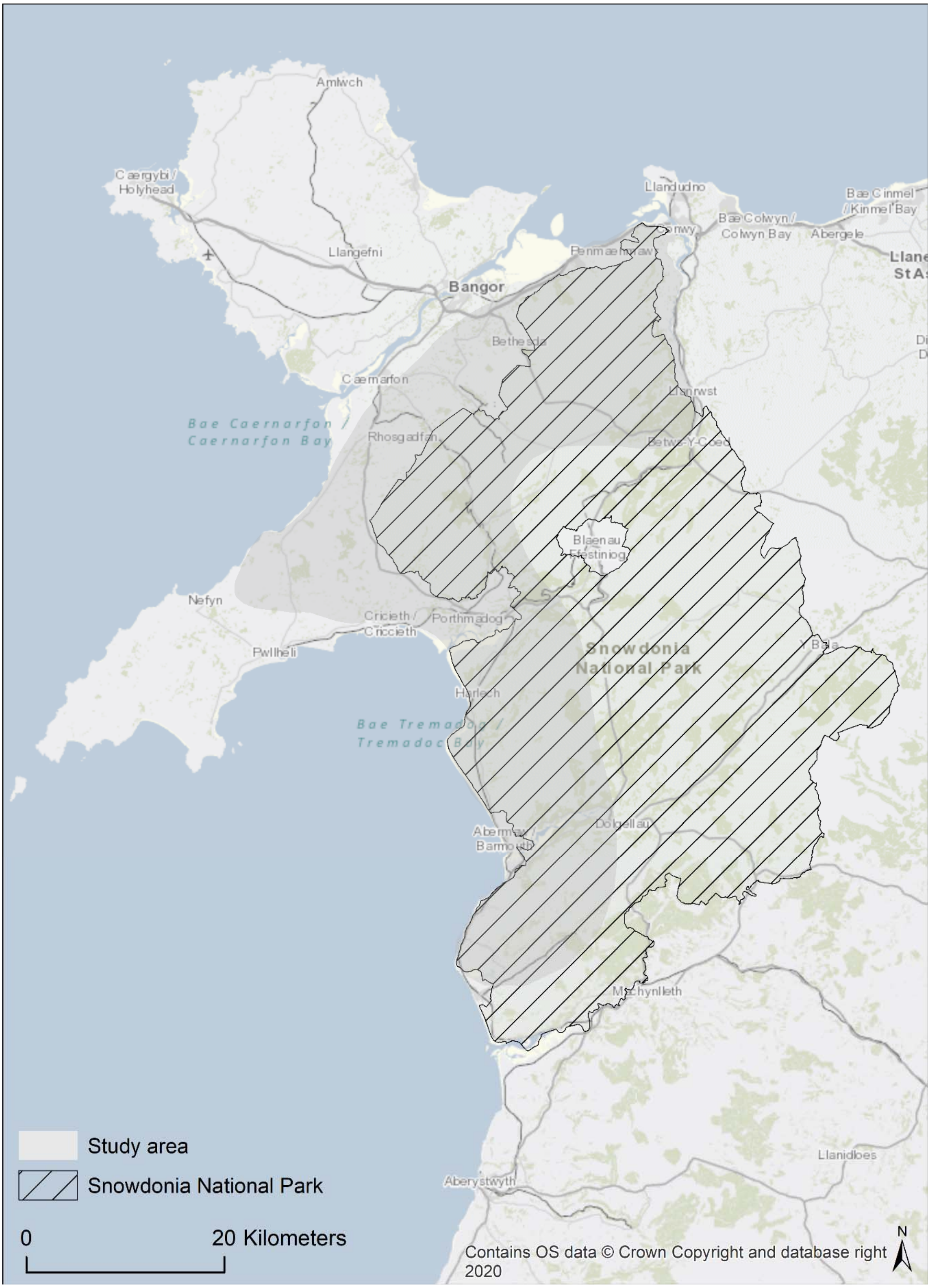

Figure 1.2
Map showing study area in relation to Snowdonia National Park

Chapter 2
Historiography of Early Fieldscapes in northwest Wales

Introduction

Archaeologists have studied the early fieldscapes of northwest Wales for more than 150 years, excavating dozens of different sites and undertaking field and geophysical surveys. Most of this work has focused on stone-built roundhouse settlements rather than the wider landscape context in which they were set. Tracing the history of existing approaches and interpretations has involved scouring these varied sources for incidental or implied references, sometimes to field boundaries, fields systems, fields, paddocks, stock enclosures or gardens, or in other cases to more general discussion of land use and the way that communities cultivated land and husbanded stock. The importance of unpublished material cannot be overemphasised, comprising more than a third of the sources consulted as part of this review. Wherever possible, unpublished sites are referenced in the footnotes using National Primary Record Numbers (NPRNs), held by the National Monument Record (NMR), and regional Primary Record Numbers (PRNs) held by the Historic Environment Record (HER). A chronological summary of principal studies is outlined in Appendix A.

Antiquarian study

The first published investigations of early fieldscapes in the uplands of Snowdonia date to the 1860s, when Elias Owen excavated 'cyttiau' (a term for huts, spelt *cytiau* in modern Welsh) above Llanllechid in Gwynedd (1866, 1867, 1872). His use of the term 'hafottai' to understand these 'ancient dwellings' implies continuity with transhumance practices over millennia: *hafotai* being the Welsh term for upland summer dwellings, derived from the Welsh *haf*, meaning summer, and *tai*, houses. The tradition of moving cattle and sheep to the uplands during the summer months is documented in Gwynedd from the medieval period (Longley 1997, Davies 1979) and continues for sheep to this day.

Owen was the first to classify these well-preserved stone-built structures based on their size, shape, and association with other structures and walls; a typological approach which subsequent researchers have refined. Contemporary with his work were excavations by two other well-known local antiquarians, William Owen Stanley and Huw Prichard, who investigated roundhouse sites on Anglesey: Tŷ Mawr, Holyhead (Stanley 1867, Stanley 1868, Stanley 1869, Stanley 1870), and Bryn Ddiol, Llaneugrad (Prichard 1867). The studies in North Wales predate antiquarian investigations of settlement remains further afield, such as those by Dymond (1893) in the Lake District and the work of the Dartmoor Exploration Committee in Devon (Timms 1994), which were initiated in the later nineteenth century.

By the early 1900s, antiquarian interest turned to settlement remains surviving within hillforts, including some of the most spectacular examples in North Wales, such as Tre'r Ceiri, Gwynedd (Baring-Gould and Burnard 1904, Hughes 1907), Braich y Dinas, Gwynedd (Hughes 1912, Hughes 1915, Hughes 1922, Hughes 1923), and Caer Lleion, Gwynedd (Lowe 1912), though the principal aim of these excavations was to help date the hillforts. It took another couple of decades before unenclosed roundhouses and roundhouse settlements became the focus of excavation again, for example, at Rhostryfan, Gwynedd (Williams 1922, Williams 1923a, Williams 1923b), Bryn Ddiol and Din Lligwy, Anglesey (Baynes 1930a, Baynes 1930b), and at Penmon and Pant-y-Saer, Anglesey (Phillips 1932a, Phillips 1932b, Phillips 1932c, Phillips 1934). These published examples informed Gresham's synthesis of material on 'hut circles', which first appeared in the *Transactions of the Caernarvonshire Historical Society* (1941) and later in *Antiquity* (Hemp and Gresham 1944).

Although Gresham had lived in North Wales since he was a small child, developing a strong interest in its history and archaeology as a teenager, his education was at English public schools and then University College London, where met Wilfrid James Hemp; it was Hemp's suggestion that prompted Gresham to begin his survey of hut circles (Hughes 2010). The articles published in the 1940s were the first attempts to build an explanatory narrative, and they are very much of their time and class, clearly influenced by ideas of 'race' and migration advanced by prominent archaeologists at the time, such Sir Cyril Fox (1932). Gresham asks 'what is the connection between the Enclosed Homestead and the Unenclosed Groups', answering that 'they may have been contemporary, the one occupied by semi-Romanised farmers and the other by more primitive herdsmen, or again the former may have been the hafod and the latter the hendref' (Gresham 1941: 7). In his conclusion, he states that 'the archaeologist sees in the shadowy background of Prehistory the hut dwellers as a race of unknown but distinctive people'; and in the footnotes refers to an article published in the same volume, '*The Men of Gwynedd'* by Elwyn Davies (1939), suggesting that comparing the distribution of hut types with that of racial types would be a 'very fruitful line of enquiry' (Gresham 1941: 8).

Caernarvonshire Excavation Committee (1945) and survey by the Royal Commission on the Ancient and Historic Monuments of Wales (RCAHMW, 1932-1967)

After the Second World War, the work initiated by Hemp and Gresham was continued through the *Caernarfonshire Excavation Committee*, founded in 1945 to date hut sites by excavation; it subsequently became the Excavation Committee of the *Caernarvonshire Historical Society* (Gresham

1972: 51-52). Drawing on the typological approach outlined by Hemp and Gresham (1944), the first 'type' selected was a 'Concentric Circles' site at Llwyndu Bach, near Penygroes, excavated by Bersu and Griffiths in 1947 and 1948 (Bersu and Griffiths 1949). The second type selected was the *Unenclosed group* at Cwmystradllyn, also excavated by Bersu in 1950, 1953, but written up by Gresham following Bersu's death (1972). This research did not produce much in the way of dating evidence, or indeed finds, and in the absence of radiocarbon and other absolute dating methods, interpretation was based solely on typological identification and analogy.

This work was complemented by a parish by parish survey of Caernarfonshire, started a few years earlier by a small group of RCAHMW surveyors and published as inventories in three volumes (RCAHMW 1956, RCAHMW 1960, RCAHMW 1964). The 'hut settlements' are one of, if not the, most numerous monument type included in the volumes, with hundreds of descriptions and many detailed site plans. In addition, a total of 24 extensive survey plans were completed on the northern slopes of Snowdonia and on the Llŷn Peninsula. They covered a total area of more than 1,389 hectares, and depicted enclosure walls, terraces and early fields (see Appendix B). Best described as landscape surveys, they show multiple sites and larger areas in less detail, relating, for example, 'ancient field systems' to 'huts' and other features such as cairns, roads and footpaths. The accompanying text usually includes a brief description of the ancient field systems, their extent and relationship to other features such as 'cultivation terraces', 'boundary banks' and lynchets. In a small number of examples, the descriptions are more interpretative: for example, the remains that survive on Moel Faban 'represent two early farmsteads with their associated fields and grazing grounds' (RCAHMW 1956: 145). More frequent are references to the difficulty of assigning the fields to different chronological periods. In the final volume, a section entitled 'The hut settlements and native life during the Roman occupation' (RCAHMW 1964: lxxxvii), the authors provide a classificatory scheme for the roundhouses, based on the work by Hemp and Gresham (1944) and Griffiths (1951a). Like previous authors they describe two broad patterns of field systems: (1) small, sub-rectangular fields with terracing, and (2) curvilinear walling with no obvious terracing.

The RCAHMW's surveys cover large areas, anything from a few hectares to 182 hectares, and they were the first systematic landscape survey of these areas. The surveys have enduring value as impressive results of skilful fieldwork and also because in a number of cases they record earthwork boundaries and structures that were subsequently lost to state-funded afforestation and land 'improvements' schemes in the 1960s, 1970s and 1980s. The RCAHMW surveyors noted the impacts of modern agriculture, with useful commentaries on the differential survival of roundhouses and boundaries in less intensively farmed areas of land.

The RCAHMW's work formed the basis for H.B. Johnson's paper on pre-medieval fields in northwest Wales, included in an influential edited volume on early land allotment in the British Isles (Bowen and Fowler 1978). Johnson sought to understand the location of fields by exploring the environmental potential of the uplands, and how it might have affected the type, shape and function of rural settlements. He identified areas of 'discrete and definite', 'probable extent and definite', 'discrete and possible', and 'probable and possible' pre-medieval cultivation. Matching these to modern soil grade types he argued that the boundaries dividing wet and dry land are pre-medieval in date, fossilised by subsequent farming practice. In addition, he stated that cultivation lynchets do not lie on any wet ground. Unfortunately, it is very difficult to evaluate this work because the map evidence is too coarse-grained, and the reader is dependent on the assertion of association, rather than its proof. However, it remains the first sustained attempt to model environmental potential, albeit without the computing power of GIS.

Rescue archaeology, 1960s-1980s

The destruction of archaeological remains during this period of rapid development and land improvement was mitigated, as in other parts of Britain, by state-funded excavation: investigations that came to be known as 'rescue archaeology'. Some of the excavations revealed evidence of late prehistoric settlement, where the survival of associated field boundaries was also recorded. Most were initiated when other types of archaeological remains had been identified through aerial reconnaissance, such as Llandygai Industrial Estate (Houlder 1967, Houlder 1968, Musson 1970, Maynard et al. 1999, Lynch and Musson 2004, Waddington 2013: 190-192) or previous excavation, for example at Cefn Graianog[1] (Hogg 1969, Goodburn 1978, Mason et al. 1998, Chambers 1998, Waddington 2013: 223-230), and consequently roundhouse settlements and field boundaries were not necessarily the primary focus for work. These two 'sites' are in fact landscapes, subject to several programmes of open area excavation since the 1960s, allowing analysis of extensive features, including possible boundaries (Kenney 2008, Kenney 2001b).

Excavations were also carried out at two prehistoric enclosed settlements threatened by agricultural land improvement, as part of a general survey of Ardudwy carried out by Gwynedd Archaeological Trust (GAT) between 1971 and 1981 (Kelly 1982): Moel y Gerddi and Erw-Wen (Kelly 1988b, Waddington 2013: 248-251). Samples were taken for radiocarbon dating, phosphate analysis and palaeoenvironmental remains such as pollen. For the first time in North Wales, phases of roundhouse construction and use were dated, and the character of the local environment could be described in more detail. At Moel y Gerddi high phosphate levels were taken to indicate the

[1] Also referred to as Graeanog

concentration of animals within the settlement enclosure. The excavations also demonstrated the survival of several phases of occupation in the same place, with timber roundhouses and palisades replaced by stone and earth.

Development-led excavation: the effect of Planning Policy Guidance (1990)

The adoption of new planning guidance for England and Wales in 1990, Planning Policy Guidance note 16 (PPG16), and subsequent related advice[2], placed the onus on developers to mitigate the destruction of archaeological remains by paying to investigate and record them, rapidly increasing the volume of archaeological work across many parts of England and Wales. Although it was relatively slow to take effect in northwest Wales[3], several roundhouse settlements were identified and excavated in advance of or during the construction of road schemes, with an awareness of the importance of landscape context becoming increasingly apparent in methodological approaches. At Bush Farm settlement, discovered ahead of the construction of the Felinheli bypass in 1991, an enclosure wall was noted leading off from the wall of the main cob or clay-walled roundhouse, and according to the excavators 'could clearly be seen to form the base of a stone-built field wall which was still in use' (Longley et al. 1998: 201, Waddington 2013: 197-198). The roundhouses excavated at Melin y Plas (Smith 2004: , Cuttler 2012, Waddington 2013: 166-168), in advance of the construction of the A55, were also clay-walled structures, and Smith's discussion of the extensive pits and post-holes found in association with the houses sheds interesting light on the possibility that some represented boundaries. A second later prehistoric to early post-Roman settlement discovered along the route of the A55, Cefn Cwmwd (Roberts et al. 2004, Waddington 2013: 160-162), was excavated over a more extensive area. The settlement appeared to be long-lived with evidence for a possible contemporary ditched field system and small ditched enclosure, interpreted as an animal pen (Roberts et al. 2004: 27).

Four other landscape areas, excavated in advance of development, stand out for their contribution to fieldscapes research because of their large geographic extent: continued excavations at Cefn Graianog (Kenney 2001b), land adjacent to Llandygai Industrial Estate (Kenney 2008), Parc Cybi speculative business park development on Anglesey (Kenney et al. 2011, Batt et al. 2011) and Rhiwgoch (Cooke et al. 2010, Kenney 2012b). The results from these sites, some of which are still in

[2] Particularly *Welsh Office Circulars 60/96 Planning and the Historic Environment: Archaeology* and *61/96 Planning and the Historic Environment: Historic Buildings and Conservation Areas.*

[3] The number of development-led projects steadily increased from 2001 onwards. Before that, relatively few desk-based assessments and evaluations were carried out given development levels. Reliance on identifying archaeological remains during development also reduced discoveries; for example, the low density of archaeological sites revealed during the construction of the A55 on Anglesey is notable, strongly suggesting that remains were missed as a result of 'intermittent watching briefs'.

preparation or, in the case of Cefn Graianog, still being excavated, are important for demonstrating variability in form, longevity and date of boundaries and the settlements associated with them, and are discussed in greater detail below and in chapter 7.

Government funded survey: 1990s onwards

Upland surveys

The switch from government-funded 'rescue excavation' to development-led excavation resulted in a renewed focus on survey work by government agencies such as English Heritage and Cadw (the historic environment service of the Welsh Government), who were no longer solely responsible for resourcing multiple large excavations and could direct their energies more strategically. Following the publication of two key studies in the late 1980s identifying the importance, under-recording and threats to upland archaeology in Britain (Darvill and Cunliffe 1986, Darvill 1986), work began in Wales to study the uplands more intensively. Cadw initially commissioned the four Welsh Archaeological Trusts (WATs) to carry out general assessment and scoping reports, followed by systematic recording of areas of upland between 1989 and 1992 (Kenney 2014: 5). Subsequent survey work was carried out by the RCAHMW. In 1999 the WATs were commissioned to write an overview (Silvester 2003), culminating in the publication of a series of review papers collected for publication by the RCAHMW (Browne and Hughes 2003).

What became known as the *Uplands Archaeology Initiative* (UAI) continued for another 12 years, managed by staff at the RCAHMW, in consultation with stakeholders such as Cadw and the WATs. To date there has not been a review of this second phase and consequently the synthesis and evaluation presented here is largely based on unpublished reports and liaison with RCAHMW staff, principally David Leighton, who was responsible for overseeing the surveys over much of the UAI's 25-year history.

The first review identified the importance of aerial photography and, in the light of this, RCAHMW staff carried out aerial photographic mapping in advance of ground surveys between 2003 and 2014. More than 1000 polygonal or polyline GIS records were created with reasonably consistent, if limited, metadata: the purpose of the transcriptions being to provide information to assist surveyors, rather than create new National Monument Record entries. Controlled terminology was not used, so a variety of potentially relevant terms were used that could indicate the survival of early fieldscapes and boundaries, including wall, trackway, ditch, platform, cultivated ridge, and bank. In most cases no date or period was attributed to the feature because subsequent work by surveyors was intended to 'ground truth' the features and include them in the survey database.

Not all mapped areas were subsequently visited, but in Snowdonia most were. There are 13 field surveys of relevance to the project study area, carried out by a variety of different contractors between 2003 and 2015, as listed in Appendix C. The methodology was standardised following the first phase of recording (Kenney 2014: 5, RCAHMW 2005, revised 2012), comprising rapid field walking along parallel 30m traverses, or 50m traverses where the ground was steep or difficult to survey (some early studies were initially walked along parallel 20m traverses). A total area of more than 300 square kilometres was surveyed in Snowdonia using this approach.

New roundhouse sites, earthwork and stone boundaries were identified in many of the studies. However, it is clear from the reports that the experience and knowledge of the surveyors, the time of year and other survey conditions (including time) affected the number of sites identified and their interpretation. The emphasis on the collection of statistics for site type and period restricted the scope to develop an understanding of change over time or space, deferring this to others. One or two archaeologists reference research agenda priorities in their analysis; for example Railton (2011: 9) highlights the importance of identifying the structure, components and phasing of field systems in upland areas, with an eye to possible dating of some enclosures, and the presence of encroachment. In general, the surveys were focused on sites, rather than landscapes, and the assignment of monuments to a single period. In addition, the integration of the upland survey work into digital record holdings[4] is currently restricted to National Monument Record (NMR) point data, leaving many underutilised polygonal and polyline records. The lack of concordance with other records such as the regional Historic Environment Record (HER) or records maintained by the National Trust in their Sites and Monuments Record (SMR), makes it more difficult to use or analyse these datasets.

Despite these methodological and data management weaknesses, the upland surveys remain an important source of new information about early settlements and fieldscapes. Enclosures and field boundaries, some explicitly associated with roundhouses, were identified in many of the reports, and individual reports remain useful sources for specific sites.

Thematic surveys

The interpretation of roundhouses, cairns and boundaries in the upland surveys relied on a set of thematic studies by Gwynedd Archaeological Trust, commissioned by Cadw between 1994 and 2015. The following projects are relevant to the study of fieldscapes:

- *Hut circle settlements*, 1994-1998 (Smith 1999a, Smith 1999c, Smith 2001)
- *Deserted rural settlement*, 1997-1998 (Jones 1997, Jones and Thompson 1998)

[4] Digital record holdings are available online at the map enabled portal for historic environment information in Wales: Cymru Hanesyddol / Historic Wales http://historicwales.gov.uk/#

- *Field boundaries*, 2001-2002 (Roberts and Thompson 2001, Roberts and Thompson 2002)
- *Roman forts and Roman roads*, 2002-2008 (Hopewell 2003, Hopewell 2004, Hopewell 2005, Hopewell 2006, Smith and Hopewell 2007b, Smith and Hopewell 2007a, Hopewell 2008)
- *Funerary and ritual monuments*, 2004-2007 (Smith and Hopewell 2007a)
- *Prehistoric defended early enclosures*, 2004-2008 (Smith 2005, Smith 2006, Smith and Hopewell 2007b, Hopewell et al. 2008, Smith 2008)
- *Prehistoric and Roman sites*, 2008-2010 (Hopewell and Smith 2010)
- *Early fields*, 2010-2011 (Smith 2011, Macphail 2011, Caseldine 2011, Smith et al. 2018)
- *Medieval field systems*, 2015 (Kenney 2015)

These thematic studies were designed to identify sites suitable for scheduling, employing varied methodologies. They generally comprised desk-based study, usually consultation of existing records in the HER, followed by site visits and rough sketch surveys, and in a limited number of cases, small-scale excavations or more detailed survey or geophysical survey. The thematic focus on site types often means that observations about boundaries and field systems are incidental descriptions to the main study. For example, Smith's discussion of the six roundhouse settlement sites chosen for detailed topographic survey in the 1997-98 Hut Circle Settlements Project, incorporates detailed descriptions of enclosures and field systems (Smith 1999c). He describes the enclosures associated with the settlement at Moel y Gerddi as consisting of:

> 'irregular but angular areas defined partly by lines of boulders and partly by use of the natural scarp and slope edges. Also, the edge of the scarp to the east seems to have been modified slightly creating a terraced effect, perhaps by cultivation. The walls, boulder lines, define areas around the settlement, rather than separate fields, although they could be fairly restricted 'garden' plots.' (Smith 1999c: 3)

Several original surveys plans drawn up for the sites show field boundaries (1999c: figures 3, 4, 6, 7 & 18). The field system at Penbodlas[5] was surveyed because 'it was realised that it comprised an unusually well-preserved fragment of a probably medieval field system' (Smith 1999c). The field system was noted as avoiding or respecting the hut circle settlements, suggesting contemporaneity, though Smith then goes on to argue that the shape and size was more characteristic of medieval arable cultivation.

The difficulty of dating settlements and boundaries was a common theme identified in the studies of deserted rural settlement (Jones 1997, Jones and Thompson 1998) and field boundaries (Roberts

[5] PRN 418, PRN 4017

and Thompson 2001, Roberts and Thompson 2002). As with other survey programmes, researchers tasked with identifying medieval rural settlement encountered landscapes that had changed over millennia and were not always easy to ascribe to one period. The field systems associated with later medieval settlement are described in a very similar way to earlier 'prehistoric' boundaries, taking the form of 'low, denuded stone field walls (wandering walls), which in terms were often associated with field clearance... other evidence consisted of terraces or lynchets' (Jones 1997: 14). Jones and Thompson argue that 'we need to study and understand the historical processes which have shaped the present landscape, if we are fully to understand and explain the desertion of the rural landscape over time', concluding that the way forward was 'detailed survey and recording of associated field systems and walls' (1998: 33-34).

Kenney's recent study of medieval field systems (Kenney 2015) grappled with the same problems. Her detailed discussion of the reuse of earlier field systems in the medieval period demonstrates the highly contingent nature of dating based on field shape and association with rectangular houses or roundhouses (2015: 13-19). As she points out, field systems are dated to the medieval period when they are associated with the remains of stone-built rectangular 'houses' or foundations. But these buildings are most commonly post-medieval in date, with examples known from the late Roman period through to the nineteenth century (2015: 14). Several well-dated examples of early Neolithic timber-built rectangular structures have been excavated in northwest Wales. Similarly, whilst roundhouses are usually attributed to the first millennium BC, their construction is likely to pre-date and certainly post-date that period.

The coherent narratives that seek to make sense of these remains are based on typological analysis and analogy with a very small number of dated sites. As Kenney advocates, detailed survey and a much greater depth of understanding landscapes is needed (2015: 22-23). Her transcription of boundaries from lidar and aerial photographs created 4,591 polygon records and is a useful starting point for this type of fine-grained study.

Independent research and study

In addition to survey programmes funded by Cadw during 1990s, this period also saw the publication of gazetteers and synthetic reviews, such as *A Guide to Ancient and Historic Gwynedd* (Lynch 1995) and *Prehistoric Wales* (Lynch et al. 2000). *Snowdonia from the Air* was particularly influential, neatly summarising the key monument types and periods of landscape development using aerial photographs (Crew and Musson 1996). It was the first synthetic study to powerfully convey the beauty and drama of this mountainous landscape, and direct attention away from sites to landscapes. Crew and Musson interpreted the 'wandering walls and terraced fields' as evidence of pastoral farming and arable cultivation respectively, their distribution linked to elevation and agricultural potential (Crew and Musson 1996: 20). These studies share an understanding of prehistoric settlements and subsistence derived from recent models of farming and a perception of the uplands as marginal land.

In the early 2000s, Johnston and Roberts sought to develop a research model that could test these assumptions (Johnston and Roberts 2001, Johnston and Roberts 2002, Johnston and Roberts 2003). The Ardudwy Early Landscapes Project used a range of techniques and approaches to understand later prehistoric human occupation in northwest Wales, including air photographic mapping, large-scale ground survey and topographical mapping, environmental sampling and sediment studies, geophysical survey, transects of test pits, targeted excavations investigating the character and potential of deposits for dating and for soils/environmental analysis, and examining features identified by geophysical survey (Johnston and Roberts 2003: 101). Although this work remains unpublished, the approach they advocated, combining several different investigation techniques at a landscape-scale has been taken up by researchers involved in the northwest Wales Early Fields Project, detailed below (Smith 2011, Macphail 2011, Caseldine 2011, Smith et al. 2018). The theoretical ideas underpinning the Ardudwy Early Landscapes Project are outlined in their paper on later prehistoric landscapes, included in the first round of research framework papers published in 2003 (Johnston and Roberts 2003). Three research strands are highlighted:

- Constituting society and societal change
  The key premise: we cannot assume that change can necessarily be understood in broadly functional terms (whether in response to economic, climatic or demographic factors) because we cannot assume that people acted with similar rationales or had the same world views as our own.
- Occupation practices and the formation of a ‘settlement pattern’
  The key premise: we cannot assume linear progression to permanent occupied and enclosed settlement, for the same reasons outlined above, and because the evidence to support this model is weak.
- Social and material landscapes
  The key premise: understanding landscape as an active concept rather than a static backdrop or record of events and actions has important implications for the method and interpretation; it situates ‘settlement’ in a social not just material context, highlights the significance of previous occupation practices and the natural world in forming a world view.

By contrast, the research framework proposed for the later Bronze Age and Iron Age in northwest Wales characterises 'Late Prehistoric society' as 'tribal, rural, hierarchical and familial', with a hierarchy of settlement seen as reflecting an increase in the stratification of society dominated by a warrior aristocracy (Longley 2003). Roundhouse settlement is seen as constituting the basic farming unit, with their single, dispersed counterpart situated on higher summer pastures, forming part of a transhumant pattern of farming. The picture presented is a static one, though this is in part a product of poorly defined chronologies. What is shares with the theoretically explicit agenda outlined by Johnston and Roberts is its emphasis on the importance of settlement, agriculture and the need to understand the relative and absolute chronology of boundaries. Updates to the research framework in 2010 (Gale 2010, Davies 2010b, Davies 2010a) and 2014-16 (Gale 2014, Davies 2016) have also underlined the need to refine chronology and increase the depth and breadth of palaeoenvironmental studies.

The twenty-first century: new academic synthetic studies

The importance of re-examining culture-historical models of life in late prehistoric northwest Wales prompted a series of synthetic studies in the 2000s. A programme to collate and synthesise the evidence for roundhouses and settlement in northwest Wales was initiated by Robert Johnston in 2004, with funding from the University of Wales Board of Celtic Studies. A full-time researcher, Eleanor Ghey, was appointed to compile a comprehensive database of all excavated roundhouses in Wales including, where possible, unpublished sites available up to September 2005 (Ghey et al. 2007). After a pilot study of northwest Wales, a decision was made to limit the collection of information about individual houses to sites with radiocarbon dating, although details of settlements were collected for all sites with excavated roundhouses.

Analysis of the results led the authors to draw broad conclusions across Wales, highlighting the importance of a radiocarbon dating programme for Welsh settlement archaeology. The authors emphasised that the data have shown 'just how slight are the chronological foundations for discussion of the roundhouse in Wales' (Ghey et al. 2007: section 2.4). They also identified the importance of taking multiple dates per settlement, because it was common for them to have evidence for several episodes of rebuilding and alteration, shifting location of houses around a settlement and the tendency for houses to respect the locations of earlier houses.

The database formed the basis for a detailed regional study by Kate Waddington, '*The Settlements of Northwest Wales*' (2013), a comprehensive synthetic gazetteer of settlement evidence from the late Bronze Age to the early medieval period, comprising more than 900 roundhouse settlements and 100 hilltop enclosures or hillforts. The book briefly outlines traditions of fieldwork in northwest

Wales (2013: 1-5), before analysing previous studies and approaches to settlement forms and classifications (2013: 27-56). Whilst noting the weaknesses of monument classifications, Waddington argues that they are a ‘necessary evil’, creating a broad framework by which one can ‘begin to organize the settlement data and examine the nuances of past dwelling practices’ (2013: 27). Thus, monument types are used to explore settlement by analysing their spatial patterns.

Waddington begins by discussing the environmental context, drawing on palaeoenvironmental records from seven upland sites in Gwynedd[6], and two sites from Anglesey[7]. The evidence from these sites, however, reflect specific locality more than regional trends. Combined with very limited information about settlement longevity and chronological development, it makes the discussion of settlement altitude and location problematic because there is so little reliable information about the wider agricultural and pastoral landscape. Leaving these interpretative difficulties aside, Waddington concludes that the site distribution shows:

- Settlement concentrated on the edges of uplands and lowlands in the west and north;
- Sparsely occupied areas in the interior uplands of the eastern and central parts of Snowdonia;
- River valleys largely devoid of settlement;
- Hillforts and other enclosed settlements on hilltops, ridge-tops and promontory locations;
- Medium and large hillforts concentrated along the north and northwestern coastlines;
- Small hillforts, circular and concentric enclosures dominating the Llŷn Peninsula and western Meirionnydd and Arfon;
- Unenclosed and enclosed settlements of all types most frequently located on the slopes of hills and the sides of valleys;
- Unenclosed and enclosed settlements also well represented in lowland plateau and gentle slope locations.

In her discussion of the associations between settlements and fields, she reiterates the interpretations made by George Smith (2001) and the RCAHMW before him, identifying particular settlement types and terraced or curvilinear fields noting that:

- Curvilinear fields are predominantly found in higher-altitude locations (mainly between 250m and 500m OD) and are associated with unenclosed settlements, in particular scattered roundhouses and single roundhouses;

[6] Bush Farm (GA125), Cefn Graeanog II (GD45), Mellteyrn Uchaf (GD77), Bryn y Castell (GM2), Erw Wen (GM55), Moel y Gerddi (GM76), Llyn Morwynion (GM209)
[7] Bryn Eyr (AN22), Tŷ Mawr (AN55)

- Terraced fields are concentrated in lowland and middle elevation locations (mainly between 50m and 300 m OD) and are associated with both unenclosed and enclosed settlements.

Weaving these site distribution patterns into a narrative, Waddington follows Smith and others in arguing that the curvilinear fields are likely to be earlier than the terraced fields, because circular enclosures associated with them were built in the later Bronze Age and earlier Iron Age. She suggests that they functioned as animal pens or possibly provided small garden plots. By contrast the terraced fields, more commonly rectangular in size, are linked with systematic and sustained cultivation in later centuries (Waddington 2013: 70-71). The model fits with broader explanations for change during this period (Sharples 2007, Bradley 2007), including the intensification of agricultural and pastoral practices, and the development of land tenure rights, but it does not demonstrate them.

The value of Waddington's database and gazetteer to further research on fieldscapes is the ease with which this large quantity of information can be used, cross-referenced with the National Monument Record (NMR) and Historic Environment Record (HER), and critically evaluated. For example, the time-line of settlement types dated through radiocarbon techniques (Waddington 2013: 89, figure 4.1) confirms the paucity of dated sites, with less than 1% of sites having one or more radiocarbon dates. Comparison between the full list of identified settlements in the appendix and the settlement gazetteer, which provides a site biography where there has been survey and excavation, can be used to show geographic bias in research, as outlined below in Table 2.1.

In 2010, a research project was initiated to investigate the early fields and field systems in northwest Wales, the first to focus on the late prehistoric agricultural economy of the area. The *North-West Wales Early Fields Project* (Smith 2011, Smith et al. 2018), funded primarily by Cadw, sought to establish the date and nature of field systems at three locations, using ground survey, geophysical survey, excavation, palaeoenvironmental analysis and soil micromorphology: Cwm Cilio (Llanaelhaern), Briach y Gornel (Cwmystradllyn), and Muriau Gwyddelod (Harlech).

The case studies were chosen as examples of contrasting field systems that were well-preserved and protected in whole or part as Scheduled Monuments. Background research was followed by geophysical survey, by plotting of features from aerial photographs and by ground survey to add detail to existing plans. A trial trench was excavated across one boundary at each of the three case studies. The excavations aimed to understand the construction and function of each boundary, to attempt to retrieve dating evidence and to produce palaeoenvironmental and micromorphological evidence about land use from the buried soils. Peat columns were also taken from areas close to two of the field systems for pollen analysis. For the third case study there had been previous pollen analysis close to the area.

The work demonstrated the potential for geophysical survey to reveal detailed plans of early fields, including probable house platforms and evidence for cultivation, including cultivation marks, with particularly good results from Cwm Cilio. It also illustrated the drawbacks of a small-scale radiocarbon dating programme, which made it very difficult to reliably date features. The two charcoal samples taken from the buried soil at Cwm Cilio, for example, produced dates separated by several thousand years[8], and the eight dates from the Cwm Cilio and Braich y Gornel pollen cores all date to the first millennium AD or later (Smith et al. 2018).

The pollen evidence and soil micromorphology showed the potential of these techniques to provide information about episodes of forest clearance, including primary clearance, evidence for cultivation and soil fertility, and the development of lynchets and boundaries. At both Braich y Gornel and Cwm Cilio, the buried soils were less acidic and better drained compared to today. At Muriau Gwyddelod, Smith et al. (2018) concluded that the ancient soils had been acidifying since clearance and their earliest use as pasture, though this could have begun hundreds or even thousands of years before the construction of field boundaries. It was not possible to link these episodes to the creation of fields and boundaries, and the authors recommend sampling undisturbed soils contemporary with early fields, such as those buried by clearance cairns or other later earthworks (Smith et al. 2018).

In their concluding remarks, the authors discuss the relationship of the results to settlement evidence more generally, to clearance and cultivation methods, boundaries and lynchets, field system patterns, field shape and size, and inferences drawn from these results about the agricultural economy. The most convincing and interesting sections of the report concern the physical nature of the boundaries, with the evidence from all three case studies suggesting that they were not substantial enough to enclose or exclude stock, either as stone, earthwork or natural boundaries; plant macro studies also showed the general absence of plant species indicative of hedgerows. At Muriau Gwyddelod and Cwm Cilio the substantial stony banks sealed earlier soils. At Cwm Cilio, the excavated boundary line appears to have been created initially by dumping of subsoil, perhaps of a 'marking-out' bank, indicating its deliberate construction, rather than simply an accumulation of clearance stones. The geophysical survey at Cwm Cilio indicated that all the early boundaries had considerable quantities of stone incorporated within them, though they are now visible only as

[8] 3505±30 uncalibrated BP (SUERC-33062), 1920-1745 cal. BC

grassed-over terraces. They estimated that the quantity of clearance stone present in early boundaries is much higher than those in the narrow post-medieval field walls.

The future: intelligent application of scientific techniques

The North-West Wales Early Fields Project illustrates the importance of scientific techniques for early fieldscapes research and their application in securely dated contexts. It is notable that the palaeoenvironmental research framework for Wales has developed significantly since 2003 (Caseldine 2003, Caseldine 2010c, Caseldine 2010a, Caseldine 2010b) in contrast to other subject and period areas. The latest version includes an extensive bibliography, new questions and many specific recommendations in relation to early fields, settlement and agriculture (Bale et al. 2017), as outlined in Table 2.2. Although the document has a greater emphasis on the use of traditional palaeoenvironmental techniques, rather than a broad consideration of scientific methods, it demonstrates the potential for new analysis to help understand early fieldscapes.

Aligned with this need for painstaking specialist analysis, is work by Johnston who has applied the same degree of close-grained attention to survey, examining an area of small upland fields and settlements in Cwm Ffrydlas (Johnston 2008b). Recording the microtopography of the boundaries through detailed annotated plans revealed information about their junctions, inter-relationships, differential densities of structural stone, incorporation of earth-fast stone, and general character. These details revealed the complexity of their survival and, as illustrated by Johnston, their construction and histories of use. Johnston argues that this points to a gradual process of settlement and enclosure, involving repeated visits, reworking and rebuilding, transforming people's relationship to place and their persistent use (Johnston 2008b: 119). Far from being marginal land, he argues that the uplands were central to social change.

Conclusions

The historiography of Snowdonia's early fieldscapes highlights a series of related themes and long-standing approaches to archaeological enquiry:

1. The dominance of studies focused on settlements, their morphology, and the use of typological interpretative approaches. Initiated by antiquarians such as Elias Owen, who identified unenclosed and enclosed 'hut settlements' (1866), these approaches have been developed into complex numbering systems and type 'classes', most recently Smith's identification of 5 different settlement types and 17 sub-settlement types (1999b).

2. The continued influence of culture-historical models on excavation and survey strategies. While original plans developed by the Caernarfonshire Excavation Committee in 1945 to

excavate different ‘hut types’ (underpinned by an understanding that the different settlement types might correlate with distinct groups of people), dating strategies on modern excavations are often still focused on attributing sites to archaeological periods.

3. The lack of evidence for subsistence practices associated with early fieldscapes. This is related to the limited use of palaeoenvironmental techniques and other scientific research methods. A very low proportion of settlement sites and even lower proportion of field systems are securely dated.

A remarkably persistent model for early fieldscapes underlies these approaches: one where the change from semi-nomadic herding to settled farmsteads, broadly identified as taking place from the later prehistoric to Roman periods, is understood as a linear and natural process. These social evolutionary ideas derive ultimately from nineteenth-century Darwinism and have been widely critiqued by anthropologists and archaeologists as explanatory tools (Pluciennik 2001, Brück and Fontijn 2013).

Table 2.1

Roundhouse settlements, data extrapolated from Waddington (2013)

Former geopolitical areas in northwest Wales*	Total settlement sites listed in appendix	Settlements with site biographies included in gazetteer	Settlements with site biographies, expressed as a % of the total	Radiocarbon dates	Radiocarbon dates, expressed as a % of the total
Aberconwy**	114	12	11	0	0
Anglesey / Ynys Môn***	125	30	24	4	3
Arfon***	237	23	10	3	1
Dwyfor*****	321	25	8	3	1
Meirionnydd****	287	16	6	6	2
Total	*1084*	*106*	*10*	*16*	*1*

* These areas were part of the 1974 local government districts until 1996, when unitary authorities were created https://en.wikipedia.org/wiki/Districts_of_Wales
** This was a former district in the County of Clwyd
*** This was a former district and borough in the County of Gwynedd
**** This was a former district in the County of Gwynedd

Table 2.2

Questions and scientific approaches relevant to the study of Snowdonia's early fieldscapes, based on the most recent palaeoenvironmental research framework document for Wales (Bale et al. 2017)

Questions	Scientific approaches
• Is there evidence for changing landscape use to increase productivity in the Early Iron Age? • What is the evidence for changes in animal husbandry through time? • What was the reason for the construction of burnt mounds and have they had different uses? • What were the environmental effects of transhumance and lesser transhumance in both upland and coastal wetland environments, and did the practices attested in historic periods have prehistoric origins?	• The use of radiocarbon dating of cereal grain will help to date the beginnings of agriculture and changes in crop husbandry, including the speed of changes and the introduction of new crops, such as spelt wheat. • The application of stable isotope analysis to charred grain to identify the use of manuring practices may help to determine whether there were small, permanent cultivation plots or shifting agriculture and how this relates to the archaeological evidence for settlement. • The tracking of bacterial ancient DNA in pollen and archaeological sediments could be used as an indicator of human presence in the past. • The wider application of biomolecular techniques, such as the application of collagen peptide mass fingerprinting (ZooMS) to unidentifiable bone fragments, can help to determine species. • DNA analysis should be used to distinguish domestic from wild animals and to identify genetic variation in animals. • Application of computer modelling to pollen data to reconstruct past land cover. • Analysis of grain from more ephemeral settlement sites should be undertaken. • A range of techniques, including multi-element analyses need to be applied to the investigation of burnt mounds, and the formation processes also need to be considered. • Stable isotope analysis of bone, as well as providing information about the diet of and use of resources by humans and population movement, is equally important in understanding animal diet and animal movement and can therefore inform such issues as the nature of agricultural regimes and trade networks. Animal isotope analysis is also important in the interpretation of human isotope data in the same geographic area.

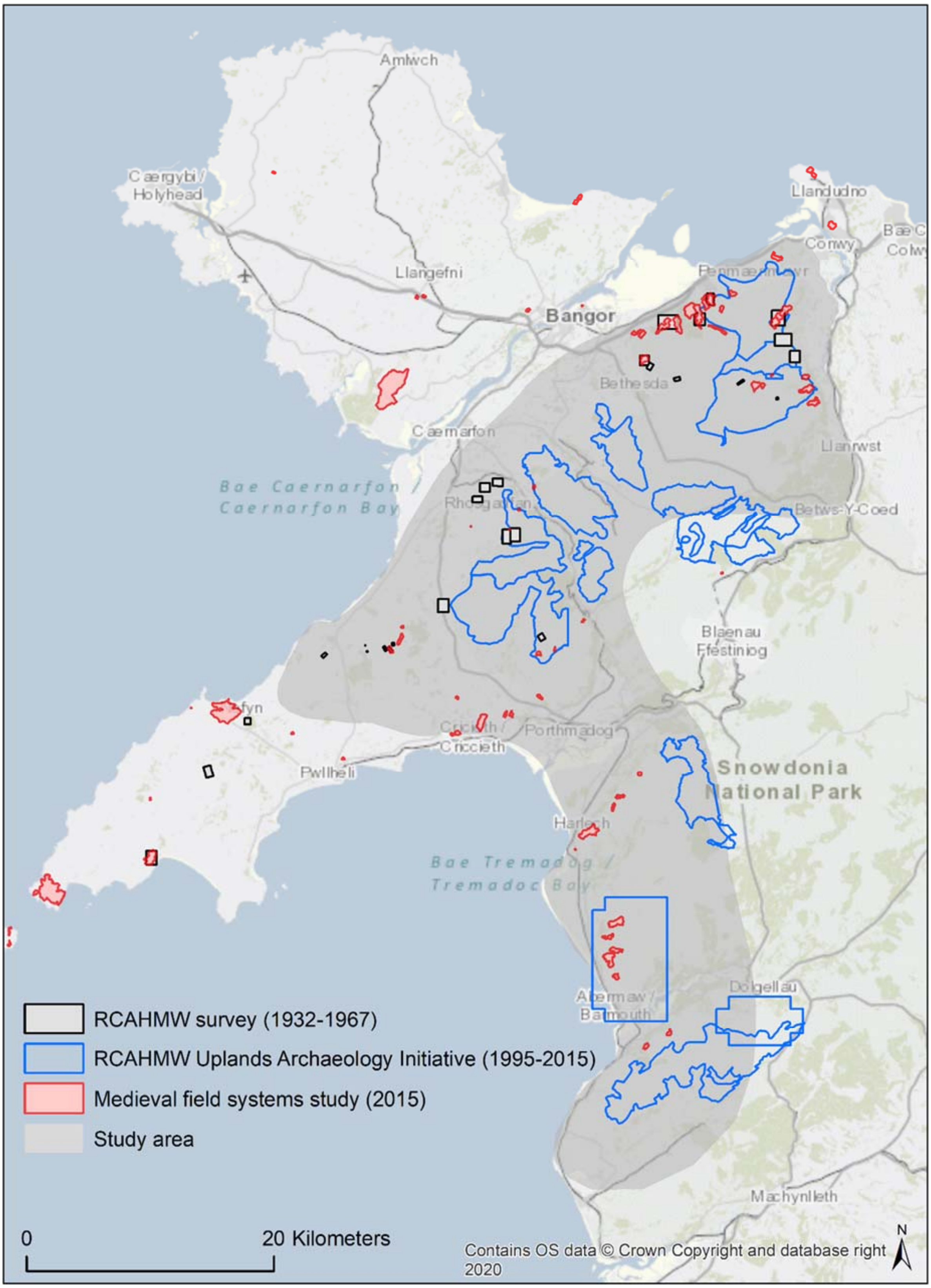

Figure 2.1
Map depicting location and extent of previous landscape surveys

RCAHMW specific survey areas (1956, 1960, 1964), Uplands Archaeology Initiative survey areas, and survey work on medieval field systems by Kenney (2015)

Chapter 3
Late Prehistoric and Roman Fieldscapes

Introduction

This chapter outlines the wider research context for the study of late prehistoric and Roman fieldscapes in Snowdonia. It comprises two main parts. The first traces its historical development as an area of academic research in northwest Europe. The second is a critical assessment of key themes and approaches, with a view to informing the evidence in northwest Wales. The review encompasses not just a large geographic area but also, as outlined in the previous chapter, a broad chronological period spanning the later second millennium BC to first millennium AD. In the light of this, the emphasis is on the last decade of research, principally in Britain. It draws on previous overviews, particularly in Bronze Age studies which have a long-standing tradition of early field and settlement research (e.g. Johnston 2013), and multi-period studies which chart the evolution of regional landscapes (e.g. Stoertz 1997, Riley et al. 2001, McOmish et al. 2002, Topping et al. 2008, O'Brien 2009, Herring et al. 2016).

English context

The original and continued impetus for understanding the time depth, extent and complexity of British landscape history is a distinctly English phenomenon (Wickstead 2008a). This is not to downplay the value of Welsh archaeology or to reinforce perspectives of the uplands and Wales as places on the margins, but to acknowledge the specific conditions that created, sustained and continue to shape its academic study. The recognition of small, gridded fields on aerial photographs of the chalk downs in southern England mark its origins in the early 1920s (Crawford 1923, Curwen and Curwen 1923). The fields were described by Crawford as 'the Celtic type' to distinguish them from later Anglo-Saxon ridge and furrow. The use of 'Celtic' as a descriptive term evoked, as Wickstead argues, ethnicity and a distinct system of agriculture and way of life associated with the 'Celtic fringe' of western Britain, Ireland and Brittany. It was part of much wider and more powerful discourses about rural life and English identity at that time (2008a: 31, 33): the term, it transpired, was also a misnomer because the fields are not typically associated with these geographic areas. Land, food production and identity, and the complex relationships between them in the past and present, have been central to landscape archaeology in the intervening century. The development of the discipline has been described and critically appraised by others elsewhere (see Tilley 2006, Bender et al. 2007, Wickstead 2008a, Fleming 2012); this thesis highlights three key areas of relevance to its study in Wales.

(1) Epistemic issues

The first is the influence of wider cultural and intellectual movements in the arts and humanities in the second half of the twentieth century, in particular their focus on the nature and construction of knowledge. Inspired by philosophers and social theorists, different theoretical approaches were explored by archaeologists based in English (and a lesser extent Scottish) universities, notably Cambridge during the 1980s (Hodder 1982, Hodder 1986). The initial application of 'symbolic and structural approaches' to archaeological materials included early prehistoric artforms (Conkey 1982), Neolithic mortuary practices (Shanks and Tilley 1982), pottery, settlement and burial patterns, and early Bronze Age burials (Shennan 1982). Applying these ideas and methods to a wider range of archaeological periods and datasets helped to refine concepts and approaches; their successors include explorations of the meaning of material culture (Miller and Tilley 1984, Gilchrist 1997), social practice (Gosden 1994) and agency (Barrett 1988, Barrett 1994). Attention shifted to space and landscapes in the 1990s, with the most influential work published by Tilley (1994) on the phenomenology of landscape.

The salient point about these approaches[9] is that they recognise archaeology as 'always already philosophical' (Wylie 2017) and are therefore committed to grappling with epistemic issues through its practice. As outlined in chapter 2, this is a perspective largely absent from the study of land division and early agriculture in North Wales, and an observation that could be applied to prehistoric studies and archaeological practice in the region more generally. While the continued dominance of traditional, culture historical accounts is similar to other parts of Britain, its persistence in North Wales is interesting given its cultural significance as the heart of Welsh-speaking *Cymru*[10] (Gruffudd 1995, Evans 2019a) and political independence movements.

(2) Intensity of new discoveries and scientific dating

The second key area is the effect and nature of development-led archaeology in England, which has resulted in more discoveries being made in areas with higher levels of economic activity. Excavations across the south of England have shown that extensive early land division covered large lower-lying areas and were not a solely, or even predominantly, upland phenomena (Yates 2007). A recent assessment of scientific dates for field systems across England, from the beginning of the fourth millennium BC to the end of the second millennium AD, has also unequivocally shown that the English landscape 'was enclosed during the later prehistoric period and that it was an ongoing, though geographically discontinuous process' (Johnston and May 2016: iii). The study was based on

[9] I have avoided using the term 'postprocessual' to lump these studies together because of its reductive effect on their distinctive character and value.
[10] Cymru is the Welsh word for Wales

a sample of 393 dates from 120 sites, most of which were discovered as a result of development. It demonstrated that large-scale land division began in the early centuries of the second millennium BC and became more commonplace after 1700 BC, revising long-held chronologies of Bronze Age field systems which had placed their inception around 1500 BC (Johnston and May 2016: 35). An abrupt hiatus in the apportionment of land and maintenance of field systems was identified during c.1000-500 BC.

There is no equivalent review of development-led (or other) sites in Wales, in part because there are insufficient dated sites. Burrow's recent summary of radiocarbon analysis in Wales outlines the principal contexts where radiocarbon dates have been obtained through archaeological, as opposed to palaeoenvironmental, work (Burrow 2018). The distribution of dates indicates that they are most frequent for established site types, and field systems are not one of the groups of sites with (relatively) high numbers of dates. Although the proportion of development-related to research-related dates is not explicitly discussed, he notes that monumental funerary sites have proved 'honey pots' for radiocarbon dating, with a high proportion of dates from Neolithic tombs (62 dates, 12 sites) and round barrows (180 dates, 60 sites), presumably the majority of which have been studied through targeted research. More frequent discoveries in development contexts include burnt stone mounds (184 dates, 64 sites) and corn drying kilns (54 dates, 24 sites), two relatively well-dated site types that do not fit neat period subdisciplines but span the earlier Neolithic to early medieval, and Iron Age to medieval periods respectively.

Several important conclusions reached by Johnston and May are applicable to Wales. They noted that in some regions of England:

- fields are frequently seen as the lowest priority for scientific dating;
- post-Roman and medieval fields remain largely inaccessible through scientific dating;
- scientifically dated sites are more common in areas with a strong research tradition relating to prehistoric field systems;
- even at sites where there have been good scientific dating programmes, these have tended to focus on early periods;
- settlement remains have been prioritised for scientific dating rather than field boundaries where both are encountered within an excavation;
- lack of scientific dating is often the result of explicit sampling strategies where funds for scientific dating are limited.

Of the three types of scientific method available to date fields across England, radiocarbon dating was the most commonly used, with occasional use of Optically Stimulated Luminescence (OSL) and one example of thermoluminescence (TL) dating on a pottery sherd in a ditch fill (Johnston and May 2016: 19). By contrast, there is only one, recently published example of OSL dating for field systems in Wales (Driver et al. 2020). Chronological reliability was also assessed by Johnston and May using the number of dates per site, radiocarbon methods, selection of material for dating and sample selection (2016: 27-34). They found that higher numbers of dates tended to correlate with longer chronologies, and that OSL dating improved precision and increased the chronological range by including periods where radiocarbon dating is less effective or ineffective, for example in medieval and post-medieval contexts. Crucially, they concluded that long chronologies need to be prioritised to rebalance overly periodised approaches (2016: 36).

(3) National research programmes

As noted in chapter 2, from 1990 *PPG16* (Department of the Environment 1990) precipitated a change in state funding away from rescue excavation. In England this led to a third significant development for landscape archaeology, with the decision by English Heritage to fund a long-term National Mapping Programme (NMP) from the mid-1990s onwards (Horne 2010). The vision for this decades-long and sustained research programme was, in part, influenced by theoretical academic trends noted above, and depended on the drive of a small number of decision-makers at English Heritage. An important outcome of this work is a recently completed five-year project investigating English landscape change from 1500 BC to AD 1086 (Gosden et al. In Press-a). This ambitious synthetic project brought together the results from the NMP, Historic Landscape Characterisation and development-led archaeological investigations, although it was completed before the publication of Johnston and May (2016) review of scientific dates.

Gosden et al. (In Press-a) set the 'formal imposition of division and enclosure within the landscape' against a changing background of heath, open land, woodland and bog across England. They identified marked differences in the degree of clearance before the end of the first millennium BC. Areas such as the West Midlands and highland areas of northern England did not have large-scale clearance before the late first millennium BC. Drawing on the work of Passmore et al. (2012) and Quartermaine et al. (2012), they argue that the small scale and comparative rarity of barrows, fields and other features was because they were created within modest forest clearances. These landscapes lie in contrast to the large field systems with a predominant alignment (so-called coaxial fields) found in more open areas in southern England, the most famous and well-studied examples of which are large-scale earthen banks and stone walls in Dartmoor, now known as 'reaves'. First recognised as prehistoric boundaries by Fleming during the 1970s, subsequent survey and excavation indicates that they were laid out as banks (or possibly hedges) around 1700 BC[11], and later given more solid form by low stone walls (Fleming 1988: 105).

At around the same time Fleming was working in Dartmoor, Pryor had started to investigate land division on the Fens, where extensive ditch systems were visible on aerial photographs. The excavations at Fengate near Peterborough revealed a series of complex ditches enclosures and drove roads (Pryor 1984). Subsequent work has shown that the process of laying out these divisions in the early part of the second millennium was broadly contemporary with the Dartmoor reaves. As Gosden et al. (In Press-a: 150) note, these large-scale projects changed the perception of the English landscape and led to many more studies that have confirmed widespread evidence of land division and land use from at least the Bronze Age onwards. The principal studies are listed in Table 3.1.

Wider northwest European context

The appearance of widespread land divisions in the second and first millennium BC is a phenomenon found elsewhere in northwest Europe. The closest parallels with the English research tradition are in the Netherlands and Denmark, where landscape archaeology and the study of early fields also began in the first half of the twentieth century (Van Giffen 1928, Hatt 1949). Earthen banks more accurately described as 'embankments' of sand and soil that accumulated between cultivated plots of land, were compared to the 'Celtic' fields of southern England because of their similar morphology (Brongers 1976). As with Britain, the literature is dominated by typological approaches (Bowen 1961), although the limitation of the 'Celtic' label has been recognised for some time (e.g. Spek et al. 2003). The popularity of landscape and economic approaches in European archaeology from the 1950s onwards resulted in new syntheses, such as Müller-Wille's (1965) and Bradley's (1978) comparative studies of prehistoric field systems (Johnston 2013). Bradley contrasted the development of *cohesive* fields with *aggregate* field systems. In England, as discussed above, Fleming introduced the term *coaxial field systems* (Fleming 1987a).

Evidence for field boundaries range from low, irregular stone-built walls, referred to as *rickles,* on the island of Arran, western Scotland (Barber 1997), to more substantial earthen embankments and lynchets in West Jutland (Odgaard 1985, Nielsen and Dalsgaard 2017). Similar embankments, known as *raatakkers*, have been found in Drenthe, a region in north-east Netherlands (Spek et al. 2003, Arnoldussen 2008, 2018). In parts of the Highlands, land division has been defined by 'cleared plots' and dykes (McCullagh and Tipping 1998); in the coastal region of Frisia, early land division and

[11] Wickstead recalibrated existing dates for the region and has showed that reaves began to be built around 1850 BC (2008b: 150).

enclosure has been identified based on areas of dense settlement and ditches (Roessingh and Lohof 2011).

Excavation and geochemical analysis have revealed evidence of cultivation and soil improvement through manuring. Episodes of stone clearance and the construction of small cairns have been associated with the creation of early fields, for example in France (Fowler 1999, Fowler 2004), southern Sweden (Lagerås and Bartholin 2003) and south-west Norway (Prosch-Danielsen et al. 2018). Understanding these 'complex and paradoxical set of sequences' (Gosden et al. In Press-a: 152) is a monumental task given the work of identifying, synthesising and analysing scattered sources of information, much of it in unpublished grey literature reports.

A detailed review of evidence from across northwest Europe is outside the scope of the current thesis. In its lieu, a list of readily available studies is summarised in Table 3.2, including a brief description of research, type of land division, principal chronological span, and main authors. This overview builds on recent work by Løvschal (2020) to identify, evaluate and compare scientific dates for field systems across northern Europe, including 7,300 dates from present-day southern England, northern Belgium, the Netherlands, northern German, Denmark and Scandinavia (Løvschal 2014b).

It seems probable that the difficulties highlighted for understanding early land division in Wales, namely, epistemic issues, lack of scientific dating and regional synthesis, are also relevant, to varying degrees, in other geographic areas in Europe. What the evidence suggests so far, is that different areas have different trajectories for the earliest dates and development of more permanent forms of land tenure boundaries (Løvschal 2020).

Key themes and approaches

Understanding the emergence of more permanent forms of land tenure boundaries is fundamentally concerned with the study of social processes and structures over several millennia. It involves the integration of evidence for land division and agriculture across different geographic and period-based disciplines, each of which have their own traditions and academic focus. The earliest evidence in Europe is found at its north western margins, in Ireland, and dates to the middle to later centuries of the fourth millennium BC (Caulfield et al. 1998, Caulfield et al. 2011), though this has been recently contested (Whitefield 2017). In other parts of Europe, for example, in the Netherlands, their appearance is not recorded until the first millennium BC (Nielsen and Dalsgaard 2017, Arnoldussen 2018).

The difficulties of working with material across such broad spatial and temporal scales are illustrated in recent disciplinary syntheses, such as *The Oxford Handbook* series: for example, *The Oxford*

Handbook of the European Bronze Age (Fokkens and Harding 2013) includes a chapter on fields and land division (Johnston 2013), reflecting a long-standing research tradition in Bronze Age studies, whereas *The Oxford Handbook of the European Iron Age* (Haselgrove et al. 2018) and equivalent volume for Roman Britain (Millett et al. 2016) do not. In European Iron Age studies, the organisation of land and food production is primarily considered in the context of households and communities (Webley 2018), and subsistence practices (Küster 2018, Groot 2018). Archaeobotanical and zooarchaeological evidence similarly dominates studies of Roman Britain (Van der Veen and O'Connor 1998, van der Veen and Jones 2006, van der Veen et al. 2008, Van der Veen 2016, Maltby 2016).

Gosden et al. (In Press-a: 153) note that there was relatively little work on fields in Roman Britain prior to the 1990s (quoting Taylor 2007), which they partly attribute to an emphasis on elements most obviously introduced into Britain by the Romans: military camps, towns, villas and temples. The countryside in Roman Britain was given greater weight by Millett (1990) and rural life is considered in detail by Mattingly (2006), but fields remained unproblematized. Agricultural intensification is generally taken as the backdrop to any changes in the organisation of rural landscapes rather than a potential object of enquiry. Laurence characterises this bias as the product of a discipline still defined by the use of texts and narrative forms that depend on the concept of Romanisation (2001).

More recently studies of rural settlement in Roman Britain signal an increasing interest in 'the exploitation of whole landscapes' (Millett 2016), and the 'archaeology of the everyday' has been identified as a major area of potential research in Iron Age studies (Hunter 2018). While these developments indicate some interdisciplinary exchange of ideas, situating Snowdonia's early fieldscapes within broader interpretations remains as much about navigating different traditions as the evidence itself. Five principal approaches have been identified from across this expansive and varied terrain as key explanatory frameworks: (1) formal or economic, (2) political, (3) social, (4) symbolic and cosmological, and (5) emergent approaches.

(1) Formal and economic approaches

Most studies of early fields discuss their economic role or use. The character of boundaries and plot size are considered in (at least superficially) empirical terms: would the height of a bank or wall be effective at keeping animals out or in (Barber 1997, Field 2008: 215), was a plot of land suitable for ploughing or not (Johnston 2005b), did trackways link different topographic areas allowing movement between natural resources such as salt marshes and upland pastures (Chadwick 1997, Chadwick 2008b, Chadwick 2007)? Palaeoenvironmental evidence is used as a source of information for understanding the cultivation of plants and husbandry of animals: were arable crops an important part of agricultural practices (Jones 1998) and what husbandry regimes were used to raise domestic livestock (Pryor 1996)? Other sources of evidence, such as phosphate analysis, have been used to argue that stock was corralled in fields or their dung used as manure to improve soil fertility (e.g. Spek et al. 2003). Fields are also related to settlements, particularly changing patterns of nucleation and permanence (Arnoldussen 2018).

While these are all reasonable questions to consider, the use of economics as an analytical tool is more problematic when it is associated with formal, neoclassical or liberal paradigms. These approaches share a narrative arc towards agricultural intensification, linking increased food production to higher population densities, the need to extract a surplus, and competition between groups. The appearance of large-scale boundaries is cited as evidence for this process (Downes and Thomas 2013). Bundling these ideas together is more common in studies where productive systems are tied to hierarchical models and change from 'simple' to 'complex' societies is understood as a natural consequence of centralised control (see Souvatzi 2013 for more detailed discussion and critique). Embedded in these interpretations are assumptions about pragmatic rationality and economic maximisation that reduce the complexities of social and cultural life to economic decisions by people in relation to land or things. This is not simply an analytical failing that risks missing critical insights, but a methodological approach that reflects particular world views.

Economic approaches also tend to explain change as the result of external factors such as climate or other natural events. In Britain the period between 1200-500 BC, for example, has long been understood to have experienced major changes because of the impact of cooler and wetter climatic conditions. The appearance of defended settlements (Thomas 1997), increases in the amount of metalwork and votive deposits (Bradley 1990), and widespread reorganisation of field systems (Cunliffe 2004) were interpreted as responses to economic crisis (as cited by Johnston 2008a: 278). Similarly, the apparent abandonment of the British uplands has, until relatively recently, been regarded as a rational response to cold, wet conditions. Yet, as Johnston notes, there is no consensus amongst environmental archaeologists for palaeoclimatic models and, from the fourth millennium BC onwards, the impact of human activity on the landscape makes it more difficult to interpret the vegetation record. Given the considerable variability in long and short-term patterns of weather, peat formation and coastal inundation across Europe, it is unsurprising that it has proved difficult to identify widespread and contiguous crises in patterns of settlement and subsistence (Johnston 2008a: 279).

(2) Political approaches

Economic approaches are frequently bound up with political approaches to land division. This is most obvious in interpretations of first millennium BC landscapes, which are dominated by the study of hillforts, but territory and political networks are also commonly discussed in studies of field systems in the second and early first millennium BC. The rectilinear land divisions in southern England, for example, are characterised by Yates (2007) as a form of conspicuous production, an 'intensification of agrarian endeavour' which developed as part of hierarchical and competitive political networks. Drawing on models of prestige goods exchange, which stress the control over production and exchange of bronze (e.g. Rowlands 1980, Kristiansen 1998, Earle 2002), he links the high concentrations of elaborate bronze metalwork found along river communication routes to the distribution of field systems and enclosures. A similar argument has been made for Bronze Age territories in Denmark (Bech et al. 2018). Although Andrew Fleming's research on early boundaries in Dartmoor (2008) explicitly avoids chiefdom or other top down models, he argues that the different scales of land enclosure corresponded with levels of social organization, ranging from individual farms to valley-based communities. He identified a series of five connected field systems, individually measuring 2,000-3,000 hectares in extent, interpreted as the territory of different communities (Fleming 1988: 55, figure 30).

There is, therefore, a certain irony that the concept employed in these interpretations of land division, *territory*, has its roots in the first and second century AD and its subsequent re-use in the fourteenth century to negotiate political power in medieval kingdoms across Europe (Elden 2013). As Elden argues in *The Birth of Territory* (2013), the emergence of the term reveals important, historically specific shifts in the way that people have viewed land and the exercise of power over it. *Territorium* appears in the writing of Pomponius and referred to lands within the boundaries of a civitas, where the magistrate had the right of *terrifying* its citizens (that is summoning or expelling). It did not apply to land beyond the Roman Empire. From its earliest inception, *territory* developed as an idea *and* a process: a political technology linked to control through coercion and violence. It was subsequently employed in the middle ages to reconfigure the relationship between the earthly royal and unworldly papal power (Elden 2013). By the eighteenth century, territory was firmly embedded in western political thought, neatly aligning spatial and temporal political and legal power to a particular place, naturalising a historically specific way of controlling resources.

Thus, as Wickstead and others have argued (Johnston 2001, Kitchen 2001, Johnston 2005a, Wickstead 2007, Wickstead 2008b, Chadwick 2008a, 2008a), the use of territory in explanations of prehistoric land division carry implicit (and sometimes explicit) assumptions about the economic and political organisation of societies. In her exploration of the idea of land and more specifically the concept of land tenure in Britain, Wickstead argues that traditional 'territorialized notions of land tenure preserve a connection between territory and identity that is homologous to the connection between nation and identity' (2007: 16).

(3) Social approaches

In the light of these critiques, alternative theoretically explicit approaches have explored the relationship between land and people. They are collectively described here as social approaches to land division. The emphasis of these accounts is on relational as opposed to territorial approaches to land tenure: rather than regarding land division in terms of scarcity, exploitation or ownership, it is understood as something that helps constitute social relationships between people. Helen Wickstead's analysis of land division on Dartmoor (2008b), for example, is an interesting contrast to Fleming's work. Drawing on sophisticated and historically situated ethnographic studies by Strathern (1988, 1999) and Munn (1986), and the work of prehistorians such as Brück (2004), she proposes that tenure should be understood as part of the constitution of identity. She argues that clustered settlement patterns and palaeoenvironmental evidence, along with coaxial land boundaries which cut across large elevation ranges, suggest that land division was not driven by land scarcity or agricultural intensification but by changes that increased grazing flexibility, including pasture rotation. She uses concepts of networked and relational aspects of personhood to argue that tenure allowed land to be distributed and circulated as parts of persons in exchange networks (2008b: 150-152).

Robert Johnston's use of kinship as a key structuring principal in his analysis of social life in the Bronze Age (2021) shares a similar ontological perspective to Wickstead, and expands on his previous work exploring land tenure, social identity and environmental knowledge (Johnston 2001, 2005a, 2005b, Johnston and Roberts 2003). He argues that field systems do not represent evidence for a fundamental change in people's worldview but were 'as complex and animate in the fourteenth century BC as the eighteenth century BC'. In place of modern conceptions of boundary-making, property and agriculture, he treats monuments and fields as comparable ways in which people related to land: both connected with routine lives and landscapes, ancestors and supernatural beings. There are close parallels between his description of kinmaking, which depended on seasonal routines and associations between people and places, and Wickstead's distributed and circulated personhood: 'in making monuments, pasture and fields, people were making kin between themselves and with other selves who inhabited the land' (Johnston 2021). Johnston emphasises the way in which boundaries were maintained and re-made. As they were extended and solidified over time, kin groups were gradually caught up in 'localities' webs':

connections that were created through seasonal patterns of labour, relationships with animals and plants, and the myths and supernatural beings that inhabited the land.

Excavation of Late Bronze and Early Iron Age buildings in the southern Netherlands have also shown that settlement changes do not conform to a simple model towards increasing sedentism. Evidence suggests that buildings were only occupied for about 20 years, after which they were abandoned, and new dwellings built elsewhere (Roymans and Theuws 1999). Land tenure proposed for these pastoral communities are based on collective rights and land. Gerritsen suggests that these involved a set of overlapping claims that allowed households rights to access and use during the life-cycle of the house but that these reverted to the wider community after the house was abandoned (1999: 94-95, cited by Wickstead 2008). A similar picture of dynamic collective and shared land tenure is outlined by Chadwick for the 'brickwork'[12] fields of the north midlands and Yorkshire. He suggests that archaeological evidence for sequences of ditch silting and re-cutting represent intermittent use of boundaries and tracks, which he links to fluctuating rights of tenure and access, with fields or blocks of fields falling out of use, only to be renewed and recut (Chadwick 1997). The unenclosed river floodplains and upland heaths may have been areas where there was inter-commoning of livestock, with access and rights of tenure determined by kinship and family ties associated with blocks of adjacent enclosed fields (Chadwick 2008a: 229).

(4) Symbolic and cosmological approaches

While relational approaches to land tenure have centred on kinship and other forms of personhood, studies with a greater emphasis on cosmological, mythic or supernatural beings are considered together in this overview, loosely described as symbolic and cosmological approaches to land division. The influence of Tilley's (1994, 1996, 1998, 2000) work exploring the phenomenology of landscapes is most evident in this group of studies, even if not always explicitly so, with an emphasis on visual aspects of experience, including inter-visibility, sightlines and significant places.

The orientation of field boundaries is a dominant theme, particularly for coaxial field systems which have a prevailing alignment. Analysis of fields dating to the second millennium BC on Marlborough Downs (Fowler 2000) and Salisbury Plain (McOmish et al. 2002) led the authors to conclude that the dominant axes were orientated northwest to southeast with corresponding shorter lines northeast to southwest. Yates (2012) expanded this analysis to include lowland sites in Dorset (Ladle and Woodward 2009), the fenlands of Cambridgeshire (Evans 2009) and the River Thames (Framework Archaeology 2006, Framework Archaeology and Lewis 2010), by aggregating their boundaries to assess potential underlying orientations. The results showed that the most prevalent axis

[12] Brickwork fields are so-called because of their morphological similarity to brick wall construction.

corresponded with the azimuth of the winter solstice (medium values of 130° for sunrise and 310° for sunset on a flat horizon). The transverse boundaries were distributed across a wider range of alignments but generally on a bearing to the midsummer solstice.

Yates argues that similarities between these lowland and upland field systems indicate that they had a widespread and shared cosmological significance. The coaxial field systems are described as 'orientated on the solar arc', with their boundaries acting as lifelines to the 'ultimate symbol of regeneration: the sunrise' (Yates 2012: 292). The association of human cremated bone within fields, increasingly identified during development-led excavations, is interpreted as further evidence of a 'supernaturally charged landscape in which people, their livestock and their cultivated crops were closely linked in a complex cosmology' (Kristiansen and Larsson 2005 cited by Yates 2012). This follows work by Brück (2001) on the physical incorporation of the dead within Bronze Age settlements and enclosures, and Fitzpatrick's (1997) exploration of the metaphorical connections between the layout of houses, the daily cycle of 'sunwise' movement from east to west, and the longer cycle of life and death.

More recently, detailed analysis of forty field systems across England by Green and Gosden (In Press) demonstrates greater spatial and chronological complexity than previously suggested. Using a more accurate calculation for sunrise and sunset which accounts for uneven terrain[13], they concluded that the precise alignment of field boundaries on solstitial directions was relatively rare. Less precise alignments were more common, and they argue that field boundaries were probably laid out in the general direction in which a solstice sunrise or sunset was understood to occur based on local knowledge. Continuity was the most striking feature of field systems: the maintenance of particular alignments, regularity, field shape and size made it hard to distinguish Bronze Age from Roman fields in terms of their broad organisation (Green and Gosden In Press). Like Yates, they draw on the work of Bradley (1998) to suggest that their construction and orientation may have also referenced earlier monuments, such as round barrows. However, they question if the associations fields held for the people who made and used them remained constant in the same way. In place of narratives that describe a shift from ritual to secular society and increased agricultural intensification, they wonder if fields were, in fact, regularly abandoned, possibly on the death of the person who created them. Fields might represent 'genealogy mapped onto the landscape', which in axial cases may have had a cosmological element (Green and Gosden In Press). They point to the regular abandonment and replacement of houses in the second and first millennium BC (Brück 1999, Sharples 2010) and the huge discrepancy between the number of fields and the number of houses, with fields massively

[13] Azimuthal bearings were converted to a metric known as celestial declination.

outnumbering houses. This accretive model fits with other interpretations (Johnston 2005a, Wickstead 2008b) that argue against top-down planning.

Social and cosmological approaches are also combined by Downes and Thomas (2013) in their study of Bronze Age and Iron Age land ownership and land use on the Orkney archipelago, off the northern coast of Scotland. They frame the interpretation of land division in the context of an 'indissoluble relationship between people and land' (Downes 2009), proposing a reciprocal rather than exploitative use of land and resources. Changes in material culture and burial practices are related to an increase in sheep husbandry, indicated by a massive increase in sheep remains in the faunal record (Albarella 2007, cited by Downes & Thomas 2013). They suggest that seasonal movement of stock between winter and summer pastures may have involved important changes to the way land division was understood - changes to large-scale landscape organisation that can be discerned on Orkney *in the absence* of coaxial boundaries or obvious field systems. They employ the Norwegian concept of *utmark* to convey the sense of separate and mythical places imbued with supernatural meaning. The intensification of stock and extensification of pastures would have involved expansion into the territory of the *utmark*.

The coaxial boundaries of Dartmoor have been interpreted by both Fleming and Wickstead as reflecting the movement of people and animals to and from pastures (Fleming 2008, Wickstead 2008b). Downes and Thomas cite these boundaries to argue that they did not function solely as enclosures but could also act as guidelines for negotiating movement through the *utmark* (2013: 75). Rather than being signs of land allotment, the massive linear earthworks, known as *treb dykes* (Lamb 1983: 176, cited by Downes & Thomas), that survive on some of the smaller islands in Orkney, may have demarcated different domains, 'an allotment of space or place to particular beings - whether animal, human, real or supernatural' (Downes and Thomas 2013: 81).

(5) Emergent approaches

The final approach considered in this review includes studies focused on long-term patterns and trajectories. The choice of the descriptive term 'emergent' follows recent debates about the use of this pivotal concept in interpretations of natural and social human life (Baggio and Parravicini 2019). While the work of Løvschal (2014a) makes explicit use of the concept and considers it on the broadest spatial scale, the synthetic archaeological studies of land division in England and Wales discussed here do not (e.g. Rippon et al. 2013, Allen 2015, Rippon et al. 2015, Smith 2016, Smith et al. 2016, Smith 2018a, Gosden et al. In Press-a). What they share, however, are important similarities with emergentism: a commitment to avoiding reductionist causal explanations, in particular any kind of dualism that presupposes independence between the material and social domains; a focus on higher-level units and relations (in the case of land division, spatial and temporal); and embrace of complexity (Baggio and Parravicini 2019).

In her study *Emerging Boundaries* (2014a) and subsequent exploration of 'deep-time trajectories' in the spread of land tenure boundaries (2020) Løvschal proposes that early land boundaries were a form of spatial technology and social categorisation that characterised a new way of organising the landscape and settlements across northwest Europe in the second and first millennia BC. Her approach to land allotment boundaries considers their development as a phenomenon analogous to the emergence of written language, with varied mutual influences at different points in time across the globe (Daniels and Bright 1996 cited by Løvschal 2020). She explores a series of interrelated, generative boundary principles to argue for their 'socioconceptual emergence' and long-term causality. Boundaries were anchored not only physically in the landscape but also conceptually: they 'became a commonly understood symbol of ownership of land and cattle, of rights and obligations, and of new social ways of being' (2014a: 725). Løvschal is particularly interested in the material and temporal dimensions of boundaries and their relationship to a deeper understanding of human conceptualization and culture-historical variation. Using four generative boundary principles - lines as markers, boundaries as articulations, boundaries as process-related devices and boundaries as fixation and formalization - she traces the way in which these principles played out differently in local chronological sequences, arguing that there appears to be something quasi-directional in particular emergent entanglements between humans, materials, and landscapes (2020: 369).

The theoretical exploration of boundaries with displaced historical trajectories is a key difference between Løvschal's work and other studies that examine long-term change. Certainly both the *Roman Rural Settlement project* (Allen 2015, Smith et al. 2016, Smith 2016, Smith 2018a) and the *Fields of Britannia project* (Rippon et al. 2013, Rippon et al. 2015) adopt conventional approaches to handling large amounts of complex information. The larger trends they discuss are synchronic, held firmly in their spatial and temporal place. The *English Landscapes and Identities project* (Gosden et al. In Press-a), by contrast, is theoretically more experimental. While acknowledging the difficulty of making sense of larger trends, Gosden also emphasises the need for new ideas about how past societies 'worked together formed internal solidarities and differentiated one from another' (Gosden et al. In Press-b: 1).

Concluding comments

The review outlined in this chapter demonstrates that land divisions appeared across many parts of northwest Europe during the second and first millennia BC. The process followed different trajectories in different places, with some boundaries continuing in use into the first millennium AD.

Enclosure was defined physically by stone walls, earth banks, fences, hedges, ditches and dykes. It also involved shifts in conceptual understanding, a process where physical evidence of division was sometimes minimal or absent. The breadth and variety of research provides a rich comparative dataset to draw on for this thesis. Studies illustrate the influence of different theoretical perspectives, from more traditional economic and political models, to approaches that explore cosmological, mythic or symbolic associations. Two key developments have been highlighted that have particular relevance for the interpretation of fieldscapes in northwest Wales: the importance of relational as opposed to territorial approaches to land tenure, and the emergence of early land division as a long-term phenomenon.

Table 3.1

Selected regional studies of early fields(capes) in England

Location	Brief descriptive summary	Principal chronological span (active use)	Author(s)
Dartmoor, Devon	50 years of fieldwork and excavation of land division primarily defined by earth banks and stone walls.	Second millennia BC	Fleming (1987b), (1988, 1989b, 1989a, 1994, 1998), Johnston (2005a), Wickstead (2008b)
Bodmin Moor, Cornwall			Johnson and Rose (1994)
The Fens, Cambridgeshire	50 years of Fen-edge excavation, with land divisions primarily defined by linear ditches.	Second millennia BC	Pryor (1984), (1996), Pryor and Barrett (2001), Evans (2009)
Marlborough Downs, Wiltshire		Second millennia BC	Gingell (1992), Fowler (2000), McOmish (2005)
Salisbury Plain, Wiltshire	More than 30 years of field work. Land division primarily defined by low banks and linear ditches.	Second millennia BC	Bradley et al. (1994), McOmish et al. (2002)
West Penwith, Cornwall	30 years of field work Penwith, with fields primarily defined by stone hedges, stony banks, lynchets (some revetted), dry stone walls and terraces.	First millennia BC and early first millennia AD	Herring (2008), Nowakowski (2016)
Yorkshire Wolds, Yorkshire		First millennia BC	Stoertz (1997), Fenton-Thomas (2008)

Exmoor, south-west England	Evolution of landscape from prehistoric to Romano-British period.		Riley et al. (2001)
Greater London, south-east England	Development-led large open area excavation (60+ hectares), with land division defined by ditches and trackways.	Second and first millennia BC	Framework Archaeology (2006), Framework Archaeology and Lewis (2010)
Southern England	Synthesis of previous studies.	Second and first millennia BC	Yates (2007), Bradley and Yates (2007)
Nottinghamshire and South and West Yorkshire	Doctoral study of 'brickwork' fields, primarily defined by ditches.	First millennia BC and early first millennia AD	Chadwick (2008b)
The Lake District, Cumbria	Detailed upland survey (1982-1989) in National Park, including cairnfields and land division defined by stony banks.		Quartermaine et al. (2012)
Northumberland	Detailed upland survey by the RCHME and research excavation, with land division defined by terracing and small cairns.	Second millennia BC	Topping et al. (2008), Passmore et al. (2012)
Wareham, Dorset	Open area excavation (1992-2005) of quarry, land divisions defined by ditches.	Second millennia BC.	Ladle and Woodward (2009)
Surrey, Wiltshire, Hampshire and Sussex	Field survey of eight areas in southern Britain, with land division defined by lynchets, linear ditches and cross ridge dykes.	Second and early first millennia BC	English (2013)
Yorkshire Dales, Yorkshire	Mapping project and subsequent doctoral study of coaxial field systems defined by stony banks.	First millennia BC	Horne and MacLeod (1995), Brown (2016)
Peak District, Derbyshire	More than 30 years of field work in National Park, including cairnfields and land division defined by stony banks.	Second and early first millennia BC	Barnatt (2008), Barnatt et al. (2017)

Table 3.2

Selected regional studies of early fields(capes) in Europe, with additions to Løvschal (2020: figure 1 and table 1)

Location	Brief descriptive summary	Principal chronological span (active use)	Author(s)
North Jutland, Denmark	Land division defined by fences, ditches, earthen banks and lynchets.	First millennium BC	Hatt (1949), Nielsen (1993), Bech (2003)
County Mayo, Ireland	Excavation and survey focused on 'Céide Fields landscape', with land divisions defined by stone walls.	Fourth and third millennium BC	Caulfield (1978), Caulfield (1983), Caulfield et al. (1998), Caulfield et al. (2011), Whitefield (2017)
West Jutland, Denmark	Land division defined by earthen banks and lynchets.	First millennium BC	Odgaard (1985), Nielsen and Dalsgaard (2017)
Shetland, Scotland	Land division defined by stone boundary walls, oval houses and clearance cairns.	Third millennium BC	Whittle (1986), Turner (2012)
North Estonia		First millennium BC	Lang (1994)
Arran, Scotland	Excavation and survey, with land divisions defined by earthen banks and stone-built walls known as *rickles.*	Third and second millennium BC	Barber (1997)
Campine, Belgium	Study of aerial photographs only, land division defined by low banks.	-	Vandekerckhove (1996)
Thy and Mors, Jutland, Denmark	Large fieldwork project (1990-1997), with land division defined by irregular fields with no or low earthen banks, ditches and post-built fences.	First millennium BC	Liversage and Robinson (1996), Bech et al. (2018)
County Clare, Ireland	Land division defined by stone walls.	Second millennia BC	Jones (1998)

Sutherland, Scotland	Study of landscape evolution, with land division defined by 'cleared plots' and dykes.	Second and first millennium BC	McCullagh and Tipping (1998)
Frisia, the Netherlands and northern Germany	Land division defined by ditches, with areas of dense settlement.	Second and first millennium BC	Roessingh and Lohof (2011)
Drenthe, north-east region of the Netherlands	'Celtic' field research project programme of Groningen University; land division defined by embankments largely made of earth, known as *raatakkers*.	First millennium BC	Arnoldussen (2008), (Spek et al. 2003),
The Meuse-Demer-Scheldt area, southern region of the Netherlands and north Belgium	Land division defined by extensive fencing and dense settlement, with embankments on sandy soils.	Second and first millennium BC	Arnoldussen (2008), Roymans and Theuws (1999), Gerritsen (2003)
Bornholm, Denmark	Land division defined by embankments and stone walls.	Second and first millennium BC	Nielsen (2000)
Languedoc, France	Study of aerial photographs with evidence of cairns and land division defined by stone walls.	First millennium BC	Fowler (1999), Fowler (2004)
Östergötland, southern Sweden	Excavation and field survey project; land division defined by stone walls known as *Strensträngar* and earthen banks.	First millennium BC – first millennium AD	Petersson (1999), (2008)
Normandy, France	Excavation on the island of Tatihou with land division defined by ditches.	Second millennium BC	Marcigny and Ghesquière (2003)
Hamneda, Southern Sweden	Fields defined by clearance and cairns.		Lagerås and Bartholin (2003)

South-west Ireland	Study of evolution of early settlement landscapes and upland farming, with land divisions defined by curving stone walls made up of loose stone and boulders.	Second and first millennium BC	O'Brien (2009)
Orkney, Scotland	Land division defined by massive linear earthworks known as *treb dykes*.	First millennium BC	Lamb (1983), Downes and Thomas (2013)
Scotland	Synthetic overview of fields and farming.	Second millennia BC	Halliday (2017)
Jæren, southwest Norway	Study of landscape evolution; land division defined by lynchets, with evidence for cairns and ard furrows.	Second millennium BC	Prosch-Danielsen et al. (2018)
Galway, west Ireland	Excavation and field survey project; land divisions defined by drystone walls.	Fourth and third millennium BC	Jones (2016), (2019)

Chapter 4
Methodology

Introduction

This chapter describes the methodological approaches developed to identify early fieldscape features. It is split into two sections: the first briefly reviews regional and national aerial mapping programmes in England, Scotland and Wales, along with the use and analysis of lidar datasets; the second section outlines the methods chosen for the early fieldscapes dataset in the light of this review. These include the processing and analysis of lidar datasets, the creation of new spatial datasets, the selection and use of existing content and spatial datasets, digitisation, post-digitisation data checking and cleansing, and fieldwork. Workflows, methodological developments and difficulties with feature recognition are also discussed. Recommendations for future work are made in the conclusion. Detailed discussion of analytical methods is not included in this chapter; they are discussed in chapters 5 and 6 because they were developed following feature identification and form part of the interpretation of results.

British regional and national aerial mapping programmes

Archaeological features have, as outlined in the preceding chapters, been mapped from aerial photographs since the 1920s, but the first large-scale surveys did not begin until the 1980s, when English Heritage sought to build on pioneering regional studies through the development of a National Mapping Programme (NMP). Following pilot work in the late 1980s and early 1990s more than 30 studies have been completed. Unfortunately, no overview or synthesis of this programme had been carried out at the start of this thesis though there was a short interim paper published by Bewley (2003), and more recently some review papers by Winton (Winton and Horne 2010, Winton 2015, Winton 2016). Pre-NMP, pilot NMP and full NMP projects were evaluated based on summaries held by the Archaeology Data Service (ADS)[14], and on reports available through the Historic England (formerly English Heritage) website. This brief review indicates that lidar started to be used in these studies as a data source in the late 2000s (e.g. Deegan 2013).

Although outside of the scope of this research, more substantive synthesis of national mapping programmes would make it easier to build on previous work and would provide a valuable opportunity to consider the wider contribution of these studies to the discipline. This could include both a quantitative assessment, for example, the percentage of England's landmass covered by the

[14] http://archaeologydataservice.ac.uk/archives/view/NMP/

NMP, the development of metadata standards and creation of spatial records, and its qualitative impact, for example, the way in which findings have influenced or changed different understandings of landscapes. Synthetic review is also missing from the aerial mapping programme in Wales, primarily as part of the Uplands Archaeology Initiative (described in more detail in chapter 2), which began at around the same time that the NMP was being developed in England. The absence of critical overviews has required some detailed examination of original metadata and appendices, where they are available.

The situation in Scotland differs from both England and Wales: while there is national coverage for the Historic Land-use Assessment (HLA), systematic and detailed archaeological survey has been undertaken for relatively small areas of the country. Field survey projects by the former Royal Commission on the Ancient and Historical Monuments of Scotland (now a part of Historic Environment Scotland) since the mid-1980s showed that mapping visible topographic archaeological remains increased known sites by between 50% and 200% (Banaszek et al. 2018). The recognition of high-quality surveys with low total land area coverage in Scotland prompted a new approach, recently trialled on Arran (Cowley and López-López 2017, Banaszek et al. 2018, Cowley et al. 2020). The methodology for this project, described as 'Scotland in Miniature', was developed by the Scottish team using airborne laser scanning (ALS) as the primary source for the identification of earthworks and other archaeological remains (working with a digital terrain model at 0.5m spatial resolution), with targeted field reconnaissance and observation to explore specific issues with identification and areas of weakness in the ALS data (Banaszek et al. 2018: 13). This work began during the development phase for this thesis and was not therefore a major influence on it, though there are similarities in their approaches and workflows.

The different regional and national aerial mapping approaches adopted in England, Scotland and Wales highlight two key areas relevant to the early fieldscapes research, where variations in traditions and current practice are discussed in more detail below:

1. the coverage and use of lidar datasets for archaeological feature recognition;
2. the use of digital datasets and metadata standards in aerial mapping programmes.

(1) Lidar datasets

Lidar coverage and quality varies significantly between England, Scotland and Wales. More than 60% of England is covered by composite 1m resolution survey[15] and about 75% covered by 2m resolution

[15] https://data.gov.uk/dataset/80c522cc-e0bf-4466-8409-57a04c456197/lidar-composite-dsm-2017-1m last accessed 10 November 2020

survey[16], with similar coverage in Wales[17], whereas no percentages are quoted for Scotland by the Scottish Government and cursory examination of mapped datasets indicates coverage below 50%[18]. The collection dates for these datasets and their availability to the public has also varied, with Scottish data lagging behind England and Wales, only becoming accessible in October 2017 (Isenburg 2017). This has inevitably affected their use by archaeologists.

The potential of lidar for archaeological research in the UK was recognised at a NATO sponsored workshop held in Leszno, Poland in November 2000, organised to discuss future practices in aerial archaeology, and how they might be applied across Europe[19]. English Heritage used lidar for the first time in 2001, as part of a review of mapping for Stonehenge, and since then it has become a standard data source for mapping and interpretation projects in England (Grady 2017). Guidance on the use of lidar was first produced by England Heritage (Crutchley 2010), and recently updated by Historic England (Historic England 2018). The general methodology recently employed by NMP projects is outlined by Bax (2015: 10):

1. Environment Agency lidar 'American Standard Code for Information Interchange' (ASCII) file data used for processing.
2. Processing carried out using the Relief Visualisation Toolbox (RVT), a stand-alone computer program, written by Ziga Kokalj and colleagues at the Institute of Anthropological and Spatial Studies at the Research Centre of the Slovenian Academy of Sciences and Arts (Kokalj et al. 2016).
3. Georeferenced tiff files imported into AutoCAD Map 3D in the same manner as the rectified air photographs.
4. The identified archaeological features mapped from the rectified air photographs and lidar using AutoCAD Map 3D.

(2) Digital datasets and metadata standards

Analysis of the English NMP studies shows the gradual development of standards and approaches to working with digital datasets. It is possible to trace the development of mapping conventions, organisation of digital data, documentation of digital data, approaches to interpretation, presentation of results and integration of new data into existing databases.

[16] https://data.gov.uk/dataset/fba12e80-519f-4be2-806f-41be9e26ab96/lidar-composite-dsm-2017-2m last accessed 10 November 2020
[17] http://lle.gov.wales/Catalogue/Item/LidarCompositeDataset/?lang=en last accessed 10 November 2020
[18] https://remotesensingdata.gov.scot/data#/map last accessed 10 November 2020
[19] https://historicengland.org.uk/research/methods/airborne-remote-sensing/lidar/

The most recent studies of the South Downs (Carpenter et al. 2016), Cheshire (Hardwick 2017) and Staffordshire (Carpenter et al. 2018) have digitised archaeological features directly in GIS using georeferenced lidar datasets, with separate layers created for features that have different symbology (i.e. their graphic depictions). Structuring the data is this way is based on the use of AutoCAD and reflects the original shift from paper (analogue) survey to digital transcription. Thus, the legacy of paper-based field surveys continues to structure the collection of digital data, reducing both the speed and accuracy of data capture and its analytical potential, because GIS functionality is not fully utilised.

In addition, the non-hierarchical use of descriptive terms, such as 'bank', and more specific, interpretive terms such as 'area of ridge and furrow' or 'modern feature', reflects the lack of national standards to describe evidence from aerial reconnaissance. Explicitly interpretive 'monument' data comprise more coherent datasets in GIS, and recent projects make consistent use of standardised and agreed terminology, such as those detailed in the Forum on Information Standards in Heritage (FISH) Thesauri[20]. No projects, however, have fully utilised GIS functionality in this context through drop-down menus for controlled terminology.

The documentation of these datasets does not meet the UK's national metadata standard for geospatial information, UK GEMINI standard (Association for Geographical Information 2012, Association for Geographical Information 2015), with poorly documented mapping criteria for transcription and interpretation. The dissemination of results is also variable. Although most studies are available as grey literature reports via ADS, access to original digital datasets is inconsistent.

Thus, a combination of factors - legacy data structures, poor metadata and limited access to original datasets - has restricted their re-use, particularly for more sophisticated geospatial analysis. As a result the primary use of datasets has been for descriptive rather than analytical purposes, though there are exceptions (e.g. Green and Gosden In Press).

In northwest Wales, there are two main aerial mapping digital datasets that have arisen from national or regional programmes and are relevant to work on early fieldscapes: the aerial mapping for the *Upland Archaeology Initiative*, by the RCAHMW, and a study of early medieval fields (Kenney 2015). The metadata for these projects reveal some of the same weaknesses as English studies, such as the lack of controlled terminology and failure to integrate spatial data into the HER or NMR. Where available, both used simple hill-shaded lidar models, rather than combining different visualisations or use of the RVT. Working with these datasets has underscored the value of

[20] http://www.heritage-standards.org.uk/fish-vocabularies/

incremental data acquisition, the importance of making datasets available to future researchers and, as recently observed during the 'Scotland in Miniature' trial on Arran, (Cowley et al. 2020) the need to document processes and sources of information in greater detail.

Methodological approach

The review of national and regional mapping programmes highlighted several important areas where methodological decisions are required. These go beyond areas which have been the focus of previous academic work, such as lidar processing techniques and feature recognition, to include GIS software; geodatabase schema; workflow; digitisation methods; fieldwork; data checking and cleansing.

Processing raw lidar models

The composite 1m lidar coverage for the project study area is shown on *Figure 4.1*. Digital terrain models (DTMs) and digital surface models (DSMs) were downloaded from the Welsh Government Geo-Portal[21] as ASCII (American Standard Code for Information Interchange) files. These datasets were processed using the latest version of the Relief Visualisation Toolbox (RVT, versions 1.2 and subsequently 2.2.1)[22], as detailed in the software manual (Kokalj et al. 2016). Small seamless layers were created from an average of six tiles, before standard RVT visualisations were generated for DTMs, as listed below:

1. Analytical hillshading from a single light beam;
2. Analytical hillshading from multiple directions;
3. Principal component analysis of hillshading;
4. Slope gradient (can be used to exaggerate change of slope);
5. Simple local relief model (can be used to remove large scale morphological elements, such as mountains);
6. Sky-view factor (diffuse illumination);
7. Anisotropic sky-view factor;
8. Openness – positive;
9. Openness – negative;
10. Sky illumination;
11. Local dominance.

The degree to which different visualisations reveal archaeological features varies according to several factors, including slope and vegetation cover, and all standard approaches were therefore

[21] http://lle.gov.wales/home?lang=en
[22] https://iaps.zrc-sazu.si/en/rvt#v

used. DSMs were initially not processed using the RVT because the results from other mapping programmes are equivocal: on the South Downs, for example, the DSM was not processed because of extensive woodland cover, but on islands and coastal areas studied by the CHERISH project team, where there was low tree and vegetation cover, both DSM and DTM visualisations were used (Hunt 2017). For the early fieldscape dataset, a decision was made shortly after digitisation began to process DSM using analytical hill-shading from multiple directions because it helped to inform assessments of data point return, particularly in areas with dense concentration of vegetation such as gorse. Some additional visualisations were processed on a case-by-case basis.

GIS Software

The decision to transcribe and interpret features in GIS, rather than a CAD environment, was based on its data management and analytical functionality. The decision to use licenced ArcGIS Desktop software rather than its open source competitor, QGIS, was made for the following main reasons:

1. Cost was not a consideration because the University of Sheffield provides access to all ArcGIS geoprocessing tools via an Advanced (ArcInfo) licence.
2. ArcGIS Model Builder is better at automating geoprocessing workflows; the equivalent functionality delivered through QGIS, Graphical Modeler, is more prone to crashing. This was an important consideration because of the duplication of workflows.
3. ArcGIS allows the selection and standard application of relevant metadata standards, in the case of this project, GEMINI2.3.
4. ArcGIS has a greater variety of specialised geoprocessing tools available as plugins via Esri's app store, ArcGIS Marketplace, providing greater scope for data analysis.
5. The network analyst capability is more powerful in ArcGIS. This tool helps spatial analysis of characteristics such as movement in a landscape, proximity of features to one another and origin-destination cost matrix, which may be important analytical lines of enquiry.
6. Although QGIS can handle a far greater range of GIS formats than ArcGIS, the range of external datasets for the project is modest. Only a handful of MapInfo files needed to be converted, derived from Gwynedd Archaeological Trust (GAT) generated projects, and converting these for use in ArcGIS is not difficult.
7. ArcGIS includes two stand-alone programs that allow 3D analysis. Using a 3D analyst extension *ArcGlobe* can perform fly-throughs; *ArcScene* allows vertical exaggeration and 3D modelling. This functionality is important for both the analysis of lidar and digital surface models (DSMs), and as part of the conservation element of the project, which may require creative and engaging presentation of information.

8. *ArcGIS story maps* also offer potential functionality for communicating project information to a wide range of audiences.
9. ArcGIS animations allow time-enabled fields to display data change over time; this capability could prove valuable if some features are known to overlie others and chronological sequencing can be established.
10. The topology toolbar in ArcGIS is a powerful way to check GIS errors such as overlaps and gaps.

Digitisation

The criteria and detailed methodology for identifying and digitising (transcribing) features is not well documented in national and regional mapping programmes because, as outlined above, work practices and standards are a product of incremental development from paper-based survey plans and a tradition of narrative accounts. The creation and use of datasets by a relatively small number of specialists is also likely to have contributed to a high level of assumed or implied knowledge.

In line with the broader recognition that integrated approaches are key to more comprehensive interpretations of landscape processes (Ivanišević et al. 2015: 7), a large number of existing geospatial datasets were used to inform the digitising process. In addition to the 11 different lidar DTM visualisations and hillshade DSM visualisation, modern and historic Ordnance Survey maps, modern and historic natural colour and infrared aerial photography, monument data for designated assets (scheduled monuments), national and regional historic environment records (HERs), geological and soil datasets, and environmental datasets such Sites of Special Scientific Interest (SSSIs) and land-use types (see Appendix G for a full list of resources) were also systematically checked for relevant information. In addition, geospatial datasets were created from existing content, such as RCAHMW surveys (1937-1962), the Welsh radiocarbon dates database (Burrow and Williams 2008) and medieval field system study (Kenney 2015). All sources were assessed in combination with one another, on a one square kilometre tile by tile basis.

Unlike national mapping programmes, the early fieldscapes research did not require comprehensive digitisation of monuments, highlighting the need to establish a clear rationale for the inclusion or exclusion of features: some criteria were developed in advance of digitisation, others emerged during the process of digitisation. The enormous scale of the task was evident from preliminary examination of the lidar models and a decision was made to exclude extant field boundaries or field boundaries that were depicted on later nineteenth-century sources, principally the 1st edition Ordnance Survey maps, even where the DTM or other evidence suggested an earlier date. Assessment of these field boundaries is recommended for future work, as discussed in the concluding chapter. A broad-brush approach was adopted for the inclusion of other monument types, encompassing known monuments or features associated with known monuments, from the second millennium BC to the end of the first millennium AD.

A decision was also made to use a Wacom Intuos Pro™ large pen tablet[23], in the light of research demonstrating improved speed and accuracy compared to digitising with a mouse (Kim et al. 2015). The use of the tablet allowed detailed digitisation of individual polygonal objects at a minimum scale of 1:2,000 or more frequently 1:1,000. Small or more complex features were digitised at 1:800. Transcribing features at these scales captured information such as gaps in field boundaries and more subtle changes in bank width. The quality of feature survival was not recorded in a systematic way, for example, where lidar visualisations appeared to show features very clearly (or poorly), but observations about the transcription process could be included in a notes field[24]. Although field survey work did not inform initial digitisation, many features have been visited by previous field workers and references to this information was included where relevant. If corroborative evidence was weak or missing, recommendations were made for field survey work[25].

Geodatabase schema

Structuring (ontology in information science) and documenting the digitising process, as well as core feature data gathered through this work, is important because the significance of information may not be recognised during its original capture. While this is not unique to working in digital environments, see for example work by Johnston and his detailed analysis of original survey annotations for Cwm Ffrydlas (Johnston 2008b), the impact of data structure and documentation is amplified with large datasets.

Information was collected in a newly created *Fieldscapes geodatabase*, comprising primary geospatial datasets (Table 4.1), and supplementary geospatial datasets (Table 4.2). A third group of new geospatial datasets were generated through further analysis and are discussed in chapter 6 (Appendix L).

The decision to collect two closely related but separate primary geospatial datasets was a significant departure from the approach adopted by previous mapping studies, where datasets have often been created for each monument or feature type, resulting in multiple layers (see Appendix F, Tables F1, F2 and F3). The separation emphasised the difference between the surviving *form* of archaeological

[23] Model PTH-851, Control Panel Version 6.3.15-3, Driver Version 6.3.15-3 © Wacom Co. Ltd., 1998-2016 http://101.wacom.com/UserHelp/en/WDC.htm
[24] 'Transcription_comments' (see Appendix I, Table I4)
[25] 'Recommend_field_visit' (see Appendix I, Table I4)

remains (the transcription dataset) and their interpretation as an archaeological *monument* (the research categorisation dataset). Although these concepts are commonly used in historic environment point record attribute fields, dividing them in this way was a novel approach. The aim was to improve the accuracy and analytical potential by increasing the granularity of geospatial attributes for each dataset (Appendix I, Table I4 and Table I13). Thus, all transcribed features are individual objects, whereas an individual monument in the research categorisation dataset can comprise several objects with different forms. For example, the remains of a hillfort, identified in geospatial terms as one monument, may survive with evidence for several different features such as earthwork banks and ditches, defined in the transcription dataset as multiple objects.

ArcGIS functionality enabled the collection of information for 13 feature types for the transcription dataset (Appendix I, Table I5) and 24 monument types for the research categorisation dataset (Appendix I, Table I14). Domain coded values were also created for the primary data source used to digitise features (Table I6), positional accuracy (Table I7), priority level for site visits (Table I8), digitising scale (Table I10), the name of individuals involved in data collection (Table I11), the period attributed to a monument (Table I15), and the basis for attributing a date to monument (Table I16). Data quality and data collection efficiency was improved for these attribute fields using drop-down menus and default values. Controlled terminologies have been used where they are applicable and relevant; the feature[26] and monument[27] subtype values are based on The Dublin Core™ Metadata Initiative (DCMI) terms developed by the RCAHMW, as outlined in Appendix I.

Experimenting with the design of the geodatabase schema was a valuable exercise given the limited integration of polygonal data in national and regional records, but was only feasible because of the use of drop-down menus, controlled terminology, automated and default values (as detailed in Appendix I, Table I1). National Primary Record Numbers (NPRNs) and Primary Record Numbers (PRNs) fields in the research categorisation dataset will facilitate concordance between national and regional records. By contrast, there is no scope for concordance between the transcription dataset and existing records because feature level detail is not suitable for integration with these records; where information in national and regional records has contributed to digitising a feature, for example site visit descriptions, it is referenced in the free text field for recording additional data sources used for digitising[28]. Aside from these important relationships with existing records, attribute data was restricted to the collection of new information to avoid duplication. For example,

[26] Title: EVIDENCE (WALES) (DRAFT) https://heritagedata.org/live/schemes/19.html
[27] Title: MONUMENT TYPE (WALES) https://heritagedata.org/live/schemes/10.html
[28] 'Additional_digitising_data_source_information' (see Appendix I, Table I4)

monument titles, descriptions and scheduled monument references were not included because this information can be compiled through attribute and location selection with existing datasets.

Unlike previous datasets, the geodatabase schema for the early fieldscape dataset is fully compliant with UK and international data standards. The *Fieldscapes geodatabase* has embedded metadata in all item descriptions; summaries for the primary geospatial content are included in Appendix I. The geodatabase schema is adapted from ArcGIS guidance on design and documentation, and follows UK GEMINI standard[29] (Association for Geographical Information 2012, Association for Geographical Information 2015). It is based on the International Standard ISO 19115, and sets out the information needed to identify the extent, quality, spatial and temporal schema, spatial reference, and distribution of digital geographic data (British Standards Institution 2014). These spatial standards are referred to in the regional Historic Environment Record (HER) audit (Stockwell et al. 2015: 172), and compliance with them will help ensure efficient and timely integration of data into the HER. Adhering to these standards will also ensure that information is easy to use by people who are unfamiliar with the research or topic.

Fieldwork

The methodology used for assessing lidar transcription in the field was developed and tested during the main digitisation phase, and the results used to inform further digitisation. ArcPad was chosen as the software package for mobile GIS use because of its integration with ArcGIS. A standard ArcPad Data Manager workflow was used to upload ('check-out') datasets onto a rugged portable tablet, including the Transcription and Research Categorisation datasets for editing, along with associated vector and raster background datasets including lidar visualisations, historic mapping, aerial photography and modern Ordnance Survey maps. These files were clipped to a smaller geographic extent to reduce the size of the datasets and grouped together in a single file (an AXF file). The creation of Geodatabase Feature Class datasets rather than Shape Files enabled the use of drop-down menus during fieldwork, including subtypes and domains. Edited datasets were 'checked-in' to ArcGIS following field survey work, and any updated fields automatically integrated with the original dataset. Photographs taken for identification purposes using the tablet were automatically downloaded to a folder location referenced in the attribute data[30]. Higher quality photographs were also taken with a digital single-lens reflex (DSLR) camera and stored in the same folder location.

[29] https://www.agi.org.uk/gemini/40-gemini/1037-uk-gemini-standard-and-inspire-implementing-rules
[30] 'Additional_digitising_data_source_information' (see Appendix I, Table I4)

Methodological development

An iterative relationship developed during the data collection phase between transcribing and categorising features, developing suitable metadata and fieldwork.

The first field survey work took place part way through digitisation and highlighted two problems with feature and monument recognition, influencing subsequent workflows:

(1) Smaller features were more likely to be incorrectly identified in areas where the lidar resolution was too low. As a result, many 'mounds' included in the transcription dataset were not included in the research categorisation dataset. Instead, these features were identified in the transcription dataset metadata as high priorities for fieldwork.

(2) Lynchets were not always correctly identified because their appearance on lidar imagery was similar to banks. To address this issue with 'stepped' landforms, the profile tool in ArcScene was used to create 3D profiles of wider 'banks' to assist with correct attribution and some previously digitised features were reassessed. The use of profile graphs was noted in the 'Additional data source information' attribute field.

Terminologies were also refined to improve accuracy and alignment with controlled terminologies, and new coded values for subtypes and domains were added to both datasets, as outlined below:

(1) Transcription dataset: 'Scree bank' was added to the dataset as a subtype to allow more accurate depiction of hillforts, and a qualified bank description 'Flattened wide bank' was adopted mid-way through the digitisation process to capture important observational differences between narrower, usually better-preserved banks in the uplands and the ploughed-out banks that tended to survive in lower lying contexts. This change involved re-examination of some previously digitised features. New values were added to the 'Main data source' domain to include field survey and DSMs, and in parallel with these additions, new values were also added to 'Positional accuracy' to capture the data quality for transcription primarily based on field survey, and where lidar models had low data returns and poorer quality visualisations.

(2) Research categorisation dataset: Monument subtypes were added to the dataset in response to their identification during digitisation, mainly in relation to prehistoric monuments such as 'Burnt mound', 'Barrow', 'Long cairn' and 'cairnfield', which were identified in the transcription dataset as a mound or earthwork bank. New coded values were added to the 'Dating type' domain, to capture excavation contexts without absolute dating ('Date based on excavation and/or excavated finds'), and where association with

other features was the basis for attributing a date range. The 'Period' domain was also expanded during digitisation to include broader chronological spans in the early medieval and medieval periods.

Recommendations and concluding remarks

The development of methodological approaches during the data collection phase of this research highlighted several areas that should be considered when planning future work programmes.

Accuracy

Although the metadata was carefully designed in advance of digitisation and, where possible, amended after work had begun, the accuracy and consistency of information collected for data sources could be improved. For example, information about specific lidar visualisations was included for some features as free text in the 'additional information' attribute field but should be recorded for all features using a coded value domain. Recent work on the use of RVT underlines the importance of combining visualisations during analysis (Kokalj and Somrak 2019), and work on Arran has highlighted the importance of documenting this process at feature level using item metadata (Cowley et al. 2020). A similar approach should be used to systematically record other sources used during digitisation.

Efficiency

Information held in the regional HER was consulted consistently and rapidly because full descriptive records, including copies of reports, were accessible via embedded hyperlinks in the dataset supplied by the HER. Hyperlinks to the full scheduling description for scheduled monuments also sped up consultation of this resource.

Working at different scales

Transcription was often easier if digitising was carried out at multiple scales, particularly features with a large extent where recognising feature edges could be difficult. Although there were variations in the quality of lidar models, field survey work demonstrated that detailed digitisation of features was worthwhile, capturing information that was visible on the ground or highlighting areas for further survey.

Quality assessments

A 'confidence measure' was not developed for digitisation but assessing the quality of lidar models in advance of digitising would be a valuable exercise. Field boundary junctions were often 'noisy' and difficult to transcribe; they are more likely to be the site of buildings or sheep folds, with historic map evidence indicating frequent changes and probable re-use of stone from one structure for another. Circular or sub-circular features also appeared along boundaries and although these were sometimes a product of lidar capture, in other instances they could be observed on the ground or through geophysical survey. Characterising boundaries in greater detail, particularly in combination with field survey and descriptive detail about boundary construction, would be a valuable exercise.

The land use types shown on the 1st edition, late nineteenth century six-inch Ordnance Survey maps[31] were also a useful guide to historic land use and their effect on the survival of features, with 'furze' (common gorse), marsh, bog, rocky heathy pasture and moorland frequently depicted for areas which are still uncultivated land. These variables were not consistently accounted for or documented but would have been a valuable metric for further analysis.

Natural land formation processes

There were some specific landforms which could be difficult or confusing to assess, such as watercourses and drainage ditches or indeed anywhere that water had meandered or percolated in the past. Some geological phenomena had a very similar appearance to archaeological features on lidar models, particularly on ridges and peaks where small, circular geological features could be mistaken for roundhouses. It was also difficult to distinguish between some linear geological and anthropogenic features. It is inevitable that some features will have been incorrectly identified and the lack of published guidance in this area demonstrates the need for more research.

Feature selection

The subjective nature of interpretation (Mlekuž 2013, Kiarszys 2015) was emphasised during this research by the selective approach to digitising features, specifically the exclusion of second millennium AD monuments. Although more systematic approaches, including accurate transcription of geological features, would be better suited to generalised surveys and would reduce errors, it does not obviate the wider challenge, which is to make sense of landscape change. The complexity of feature identification suggests that artificial intelligence (AI), even with advances in deep learning (DL) (Kokalj et al. 2013, Verschoof-van der Vaart and Lambers 2019), is a long way from reliably identifying all feature 'types' because their definition is necessarily so open-ended.

[31] 'Stamps' used to depict land use characteristics are shown on a specimen sheet https://maps.nls.uk/view/128076885 and characteristic sheet https://maps.nls.uk/view/74477147

Recommendations

The following recommendations are made in the light of these insights:

1. Audit the quality of lidar models in advance of digitisation and identify specific areas where the data point return is low. Consider automatically attaching this information to features as an attribute field.
2. Include more detailed metadata about specific lidar visualisations, the use of 3D profile graphs and consultation of multiple sources, using coded values and drop-down menus.
3. During the digitisation process, use embedded hyperlinks wherever possible, to streamline source checking for scheduled monuments, regional and national HERs.
4. Digitise all features at the largest scale where they can be easily identified and make use of multiple scales.
5. Acknowledge that the identification of mounds may only be possible with detailed lidar models (minimum 0.5m resolution), but where this level of detail is not available combine lidar imagery with modern (and historic) aerial photography.
6. Consider the use of separate geospatial datasets for transcribing feature form (transcription) and monument (research categorisation). If only one dataset is created, use form and monument attribute fields to improve precision.
7. Use controlled terminologies if possible and document their use. Record the criteria and use of new terms.
8. Digitise (presumed) geological features where resources/time allows.
9. Document all workflows in detail and make these easily accessible to others.

Table 4.1
Primary new geospatial datasets

Dataset title	Description of dataset, including data type and geometry type
Transcription	Spatial dataset created as part of Snowdonia's Early Fieldscapes PhD research to show archaeological features as polygonal objects. Features identified through the analysis and transcription of digital aerial images, primarily processed lidar models. Data type: Geodatabase Feature Class Geometry type: polygon
Research Categorisation	Spatial dataset created as part of Snowdonia's Early Fieldscapes PhD research to show archaeological monuments as polygonal objects. Monuments identified through interpretation of transcribed features. Data type: Geodatabase Feature Class Geometry type: polygon

Table 4.2

Supplementary new geospatial datasets

Dataset name	Description of dataset, including data type and geometry type
Cultivation marks	Spatial dataset created as part of Snowdonia's Early Fieldscapes PhD research to show pre-twentieth century ploughed cultivation ridges. Data type: Geodatabase Feature Class Geometry type: line
Revised study area	Spatial dataset created as part of Snowdonia's Early Fieldscapes PhD research to show the final study area. Data type: Geodatabase Feature Class Geometry type: polygon
Original study area	Spatial dataset created as part of Snowdonia's Early Fieldscapes PhD research to show the area proposed for study at the start of the research. Data type: Geodatabase Feature Class Geometry type: polygon
Index to map appendix	Spatial dataset created as part of Snowdonia's Early Fieldscapes PhD research to show a numbered, sequential index to smaller scale maps. Data type: Geodatabase Feature Class Geometry type: polygon
Fieldscape survey area	Spatial dataset created as part of Snowdonia's Early Fieldscapes PhD research to show areas where field survey work was carried out during the research. Data type: Geodatabase Feature Class Geometry type: polygon
Type sites	Spatial dataset created as part of Snowdonia's Early Fieldscapes PhD research to show excavated sites with dating evidence. Data type: Geodatabase Feature Class Geometry type: point
Key environmental sites	Spatial dataset created as part of Snowdonia's Early Fieldscapes PhD research to show sites where there are relevant palaeoenvironmental records. Data type: Geodatabase Feature Class Geometry type: point
Area calculations	Spatial dataset created as part of Snowdonia's Early Fieldscapes PhD research to show the enclosed area of roundhouses, hillforts and defended enclosures. Data type: Geodatabase Feature Class Geometry type: polygon

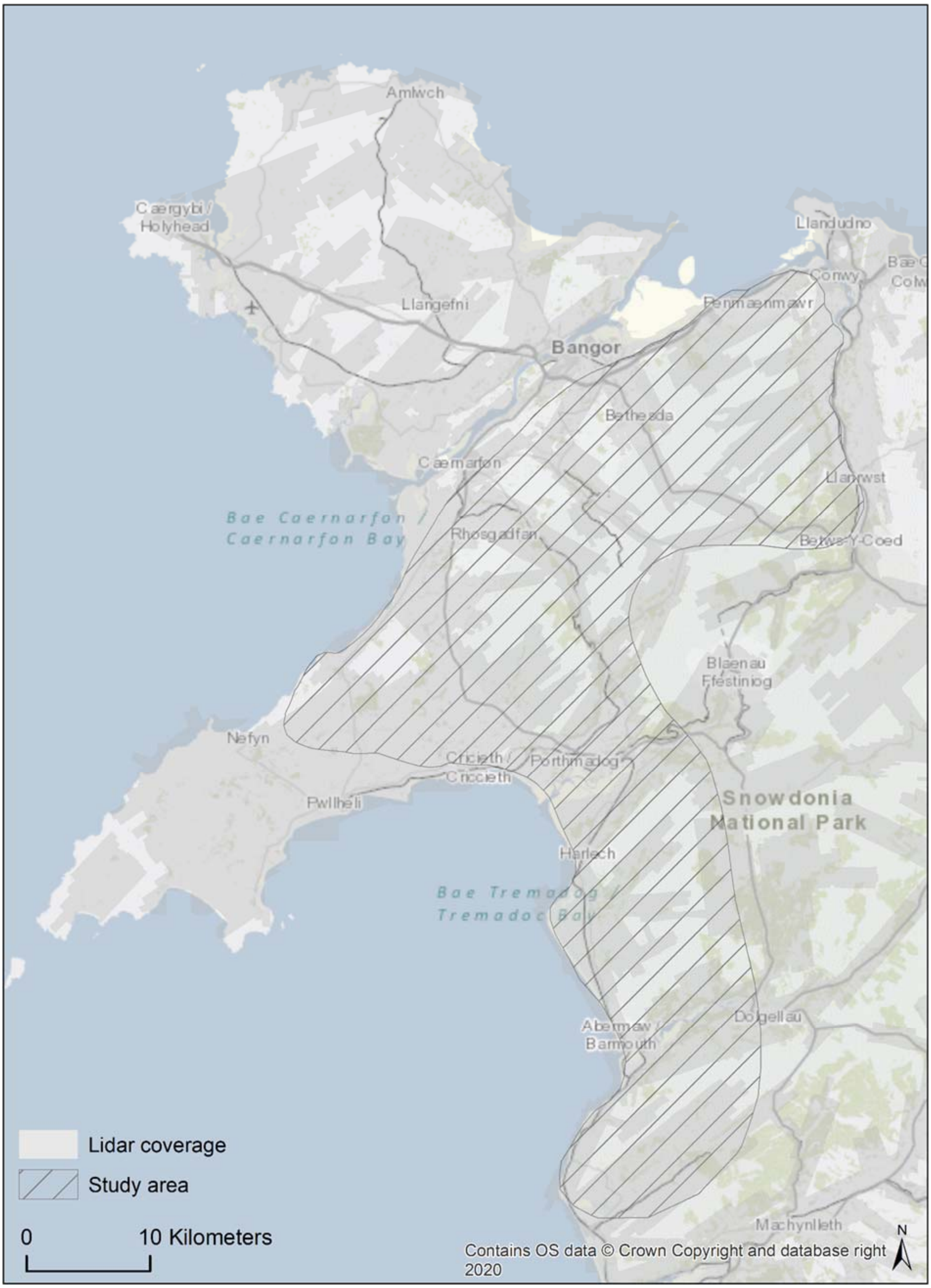

Figure 4.1
Map depicting 1m resolution lidar coverage in northwest Wales

Chapter 5
Macro-Scale Results: descriptive statistics

Introduction

The process of transcribing features from the 1m resolution lidar dataset showed that early fieldscapes survived well beyond the original proposed study area. As a result, analysis was expanded from just over 53,000 hectares to almost 142,000 hectares, largely onto lower slopes to the west and south. The original study area was based on observations made during aerial survey, analysis of aerial photographs and field survey, in addition to some initial assessment of lidar potential by Toby Driver[32]. Expanding transcription beyond the original study area significantly increased the proportion of the final study area with lidar coverage, up from 43% to 70% (Table 5.1).

Transcription dataset

A total of 13,904 individual archaeological features were identified, the majority (97%) of which were earthworks, as shown in *Figure 5.1* and *Figure 5.2*, and summarised in Table 5.2 (for a more detailed breakdown see Appendix J). Features were largely identified through analysis of the digital terrain model (DTM) visualisations, with only a handful identified using digital surface model (DSM) visualisations. A small number of features were identified through new analysis of aerial photographs and/or field survey, as supplementary data sources in specific areas. Recommendations were made for site visits to a relatively small number (3%) of all features, usually where there were issues identified during the process of transcription. Not all sites with recommendations for field survey work were visited, but a similar total number (3%) of features were assessed overall, in seven field survey areas.

Linear earthwork features predominated, with the three most common feature types described here as banks, flattened wide banks and lynchets. These terms have either not been used or not used consistently or precisely in previous studies, making it difficult to draw comparisons. However, just over a fifth of these features (21%) were digitised using additional information such as NMR or HER records, which often comprised site visit or survey detail, or were corroborated through field work. In cases where interpretation was not certain, three-dimensional visualisation or profiling was used to test slope and character to improve digitising accuracy. It is important to note that the use of these terms, even where fieldwork has confirmed the identification of linear features, can only be a

[32] RCAHMW Aerial Investigator

guide to their character and significance since their surviving form only helps partially understand their creation and subsequent use.

The creation of the transcription dataset followed national mapping conventions (Evans 2019b), with some additions made to reflect more detailed observations and measurements obtained from the lidar visualisations, including 'flattened, wide banks' and 'mounds' (as discussed in the methodology chapter 4). The results are shown on a series of 22 *transcription maps*, shown at 1:50,000, included in Appendix K and referenced in the detailed discussion below.

Preliminary analysis of these features showed:

1. The survival of ploughed-out boundaries in many lower-lying coastal areas and valleys.
2. Increased recognition of lynchets.
3. Greater detail and extent for fieldscapes where there is existing information about early settlement and fields.
4. Under-representation of negative boundary features.
5. Areas where poor quality 1m resolution lidar resulted in the identification of few or no archaeological features.
6. Important areas of known fieldscapes where there is no 1m resolution lidar coverage.

(1) Survival of ploughed-out early boundaries

The distinction between 'flattened, wide banks' and 'banks', and the association of the former with lower-lying agricultural land, provided good evidence for variable earthwork preservation, indicating areas where more intensive land-use has resulted in ploughed-out field boundaries. These were the most common type of feature identified outside the original study area, surviving in the lower-lying coastal areas and valleys, often underlying larger, straight-edged 'improved' fields of the later nineteenth century. Transcription from several lidar visualisations increased the recognition of these more subtle features, showing up particularly well on simple local relief models (SLRM), as shown in *Figure 5.3* and *Figure 5.4*.

Some wide banks formed coherent patterns of enclosure. The group of low banks detected on mid-slopes between Pentir and Caerhun, for example, follow land divisions shown on the 1840s Tithe map but not on the 1st edition (1890s) Ordnance Survey mapping (*Figure 5.3*, transcription map 1). In other areas, such as the Conwy valley (*Figure 5.5* and transcription map 3), ploughed-out boundaries can only be traced in some of the larger, later nineteenth-century fields. The network of boundaries visible on the coastal lowlands between Abergwyngregryn and Llanfairfechan echo some of the fieldscape features visible on the higher slopes (*Figure 5.6* and transcription map 2), whereas boundaries along the Afon Gwyrfai, between Waunfawr and Bontnewydd, are more scattered (transcription map 5).

There is convincing evidence that fieldscape patterns observed on higher slopes continue onto the coastal lowlands to the south of Harlech, with ploughed-out earthwork boundaries visible along the coastline towards Barmouth (transcription maps 17 and 18). For example, fragmentary boundaries, enclosures and mounds survive in woodland at Coed Cors y Gedol and into improved fields beyond, where they can be traced as wide banks (*Figure 5.4*, transcription map 17). Ploughed-out early features survived well in old, landed estates, such as Cors y Gedol, because parkland and other enclosed estate land has usually been less intensively ploughed and drained in recent decades. This is illustrated best on the Glynllifon Estate, where boundaries were identified in most of the open parkland and improved fields (*Figure 5.7*, transcription map 9).

(2) Increased recognition of lynchets

There was a significant increase in the number of lynchets identified in the study area as result of transcribing features from lidar models. Analysis of their distribution by elevation does not indicate they are confined to lower lying slopes but found across a range of heights up to 360m. Field survey work is required to assess these features in more detail, including the size/area of terraces, a factor which has not been recorded in this thesis: stepped features and terraces may simply be the latest or most visible remains of boundaries.

(3) Greater detail and extent for fieldscapes where there is existing information about early settlement and fields

In addition to newly recognised areas of early enclosure, the transcription process revealed more detail for areas of known early fields, refining information at site level and mapping the location of features for the first time. Open-positive lidar models were particularly good for identifying settlement features, routeways, and paths marked by double-boundaries, even for well-studied sites such as the partly scheduled 'Caerau Ancient Village'. This site was first excavated and surveyed in the 1930s (O'Neil 1936) and subsequently re-surveyed in 1947 (RCAHMW 1960: 47-51, figure 42) (*Figure 5.8*, transcription map 9). The transcription of features from lidar models improved the positional accuracy of known boundaries and added new information about the site. Using the profile tool in ArcGIS to generate cross-sections across features provided more detailed information about their height and character, highlighting areas of change and potential damage, where new field survey is a priority.

Several well-known early fieldscapes are associated with clusters of cairns, variously described as 'clearance cairns', 'cairns' or 'cairnfields', but usually not mapped or surveyed in detail. For example, irregular fields and cairns visible on oblique aerial photographs of Pen-y-gaer hillfort and the land surrounding it were not transcribed from vertical photographs as part of the RCAHMW aerial mapping project, or depicted on earlier survey maps drawn in 1951 (RCAHMW 1956). Transcription from lidar models, where they show up clearly, has resulted in more than ninety being mapped (*Figure 5.9*, transcription map 3). A similar pattern has been observed in the early fields at Cors y Gedol, Dyffryn Ardudwy, where hundreds of cairns have been identified on open pasture and in woodland on lower slopes (*Figure 5.10*, transcription map 17).

Most areas of important early fieldscapes do not, to date, have accurate polygonal records, making it hard to accurately identify their character and extent, or synthesise different phases of fieldwork. The slopes to the south of Pen-y-gaer and Moel Bronmiod, for example, have been surveyed and excavated for many years, most recently by Smith (2011) and Kenney (2015): the relationship between transcribed features, previous survey and records is shown in *Figure 5.11*. Comparing sources and studies which are decades and, in the case of maps, centuries, apart is a valuable exercise for assessing change, as shown in *Figure 5.12* which illustrates different survey and transcription phases for part of the area originally surveyed by RCAHMW (1960). Good quality metadata is critical to this process, because without it previous interpretations can be hard to evaluate; information about specific aerial photographs and lidar models, including resolution and processing techniques for lidar, are also important for assessing positional accuracy.

Detail, extent and documentation, past and present, are all themes evident in the uplands above Llanfairfechan (*Figure 5.13* and *Figure 5.14*, transcription map 2). This is an area which has been intensively studied, with hundreds of records in national and regional monument databases. The earliest survey work was carried out in 1947 by the RCAHMW (1956) and more recently Commission staff transcribed features from aerial photography (2004). A study of medieval fields by Kenney (2015) also involved transcription from aerial photographs, along with analysis of hillshade lidar models. Nevertheless, systematic analysis of different lidar visualisations has revealed fieldscape features surviving over a larger area than previously recognised; higher resolution lidar will undoubtedly refine our understanding further, underlining the importance of accurate and detailed records for digitised datasets.

(4) Under-representation of ‘negative’ boundary features

Negative boundary features such as ditches, hollows and pits, comprise only a fraction (2%) of the total transcription dataset. Many are associated with other features, such as hillfort ramparts; open-positive lidar models show up the features particularly well, illustrated by the substantial ditch at Carn Pentrych (*Figure 5.15*, Appendix K transcription map 13). Of the hollows, most represent scoops and non-linear features, with only a handful indicating 'hollow ways'; an example survives to the north of Cors y Gedol, Dyffryn Ardudwy (*Figure 5.16*, transcription map 19). Less common are ditches or hollows that appear to form part of a coherent group of boundaries, with no convincing examples which are not directly associated with earthwork banks.

The dominance of positive earthworks in the dataset is likely to reflect more than just better survival. One reason for the under-representation of negative features is that they are more difficult to date. Ditches are rarely marked on tithe or 1st edition Ordnance Survey maps, which means that they cannot be identified as pre-nineteenth century with any certainty. This is illustrated in an area below Moel Eilio and Yr Wyddfa (Snowdon), where several relatively large fields are marked on the 1st edition Ordnance Survey map adjacent on the south-eastern facing slopes to the east of the Afon Arddu (*Figure 5.17*, transcription area 8). The fields are sub-divided by ditches, visible on both aerial photographs and lidar models, showing up particularly clearly on sky-view factor lidar models, but not depicted on the OS map. Some features have been transcribed by the RCAHMW as part of the Snowdon Uplands Air Photo Mapping Project (2007), but as field surveyors noted for those that were visited, the ditches and trackways were either 'not of antiquity' or could not be dated.

(5) Areas where poor quality 1m resolution lidar resulted in the identification of few or no archaeological features

There are some areas with lidar coverage where few, if any, archaeological features were identified. This includes several valleys, such as the wooded slopes above Llanberis (transcription map 6) and along the length of Dyffryn Ogwen, on either side of the A5 between Bethesda and Capel Curig (transcription map 7). Features to the south and east of the Roman fort Bryn-y-Gefeiliau (Caer Llugwy) reveal additional information about its immediate landscape context, but few other features have been identified on the steeper slopes above Capel Curig, Betws-y-Coed and Trefriw (Appendix K, transcription map 8).

Lidar models in areas of dense conifer woodland had low point density because of poor penetration through the leaf canopy, resulting in processing that either smoothed landforms or resulted in a 'prism' effect on the digital terrain model (for example, see *Figure 5.18*). In areas of less dense, deciduous woodland, improved laser scanning still produced a 'cloudy' effect that partly or fully obscured features (transcription map 11, see *Figure 5.19*). Few fieldscapes were recognised on the rugged but sparsely wooded Rhinogs, where the lidar models clearly show areas of peat working on flatter ground where the point density is better. More detailed resolution lidar may pick up more features, underlining the importance of new survey for this type of terrain.

(6) Important areas of known fieldscapes where there is no 1m resolution lidar coverage

There are several areas with field boundaries, terraces and other early fieldscape features, where there is currently no lidar coverage. The most striking examples are where the lidar ends, illustrating the pitfalls of working with data collected for non-archaeological use. Polygonal records, created through transcribing features from aerial photographs and field survey, and concentrations of regional and national point data, highlight the potential for good survival of early fieldscape features. The following areas are all priorities for high-resolution lidar survey:

- Maen y Bardd settlement and field system[33] on the slopes below Tal y Fan (*Figure 5.20*, transcription map 3), surveyed and studied for many years, most recently as part of the medieval fields survey by Kenney (2015). Several prominent features such as roundhouses and cairns[34] were not transcribed from aerial photographs.
- A large strip of land between Llanrug and Waunfawr, where the dense survival of features below 240m on slopes to the north and south, strongly suggests survival on similar terrain (transcription map 5).
- Lower slopes on the west and north sides of Moel y Ci and Moel Rhiwen, where terraces, lynchets and settlement evidence has been recognised across a wide area (*Figure 5.21*, transcription map 6).
- Caeronwy settlement and field system[35] on the slopes to the north of Nantlle (*Figure 5.22*) transcription map 10).
- Gwernoer and Glangors field systems[36] on the slopes to the south of Nantlle, including enclosures with evidence for ridge and furrow cultivation and clearance cairns (*Figure 5.23*, transcription map 10).
- Early fields[37] and areas of ridge and furrow cultivation[38] recognised on the north and west facing slopes of Bwlch Mawr, east of Clynnog Fawr (*Figure 5.24*, transcription map 13).
- Area to the north of Penmorfa, containing ridge and furrow[39], and remains of medieval long houses[40] (Kenney 2015), terraces and roundhouses[41] thought to be prehistoric in date (*Figure 5.25*, transcription map 14).

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[33] NPRN 15147, PRN 4691, Scheduled Monument CN157
[34] PRN 545, PRN 4695
[35] PRN 7986, Scheduled Monument CN179
[36] PRN 6314, PRN 7859, NPRN 308978
[37] PRN 12922, PRN 13176, PRN 14515, PRN 61559
[38] PRN 875, PRN 61946
[39] PRN 59885
[40] PRN 183, PRN 6726
[41] PRN 167, PRN 1335, NPRN 301026, Scheduled Monuments CN237 and CN239

- Field system[42] and medieval long houses[43], prehistoric roundhouses[44] and settlement[45] on slopes above Llanfihangel-y-pennant, Dolbenmaen (*Figure 5.26*, transcription map 14).
- The slopes of Moel Goedog, above Harlech, where extensive and well-preserved early fields and settlements at Muriau Gwyddelod[46], with further remains surviving to the east including roundhouse settlements[47], ridge and furrow[48], terracing[49], enclosures and cairns (*Figure 5.27* and *Figure 5.28*, transcription map 17). The large area without lidar is critically important to the study of early fieldscapes because several key excavated sites are located here.
- An extensive area on the uplands above Llanaber, where multiple fieldscape features continue onto higher ground (*Figure 5.29*, transcription map 19).
- Settlement evidence, including a circular embanked enclosure[50], roundhouse[51] and at least four large cairns[52], on Bryn Seward above Llanegryn (centred on grid reference: 26250 31170, transcription map 21).

Research categorisation dataset

The research categorisation dataset attributed monument type and date attribute fields to features, based on the polygonal extent digitised for the transcription dataset. Wherever possible, individual transcription features that formed part of one meaningful feature or monument, such as a hillfort, settlement, enclosure or road, were grouped into one categorised feature. As a result, there are fewer research categorisation features than transcription features, with a total of 10,253, as summarised in Table 5.3.

Creating a separate research categorisation dataset and combining polygons worked well for known monument types. Creating individual monuments for linear features was more difficult and they are slightly over-represented in numerical terms because their start and finish points were less clear-cut; for example, the partial survival of a single field boundary might appear in the dataset as multiple polygon features rather than as one.

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[42] PRN 59870
[43] PRN 174, PRN 2361/NPRN 15067, PRN 6753
[44] PRN 173, PRN 175/NPRN 275746, PRN 176, NPRN 309182, PRN 178
[45] PRN 177/NPRN 309181, Scheduled Monument CN313
[46] PRN 2900, Scheduled Monument ME010
[47] PRN 1053, Scheduled Monument ME098; PRN 6171 Scheduled Monument ME120; PRN 29255
[48] PRN 30440
[49] PRN 1046
[50] NPRN 302811, PRN 4876
[51] PRN 4897
[52] NPRN 310178, NPRN 310177, NPRN 302809, NPRN 310176

Beyond identifying features as pre-nineteenth century in date, most could not be dated more precisely. Of those that could be ascribed a date (roughly a third), this was predominantly by association with other features (*Figure 5.30* and *Figure 5.31*). Most were ascribed to broad time periods such as 'late prehistoric to early medieval' (74% of the total) or 'early medieval to medieval' (20% of the total). The distribution of dating evidence was skewed towards sites such as roundhouses and settlements, which have been surveyed and excavated in greater numbers, and sites with distinctive morphologies, such as hillforts (*Figure 5.32*). As anticipated, the majority of boundary and field features were either undated or dated by association with features such as roundhouses.

A fifth of transcribed features were not categorised, most significantly mounds, where half all digitised features could not be confidently attributed to a monument type in the research categorisation dataset. The problems of working with this subset of the data are discussed in more detail below. The other significant group of uncategorised features were banks. The reasons for this included low digitisation accuracy because of poor quality lidar models and overlap with later features such as sheepfolds and buildings.

Comparison between the research categorisation dataset and existing national (National Monument Records) and regional point data records (Historic Environment Record) demonstrates, as one would anticipate, that the latter have a strong bias towards discrete, individual monuments. The record concordance is summarised in *Figure 5.33*[53]. Most monuments with an existing record have been visited, photographed or surveyed, providing a rough guide to field survey by monument type. New feature recognition (the difference between the light and dark blue scatter points) was greatest for early field boundaries, clearance cairns, early settlement remains and areas of ridge and furrow cultivation. Feature recognition, as a proportional increase of known examples, was also significant for cairns, clearance cairns, areas of ridge and furrow, and routeways (*Figure 5.34*). The recognition of roundhouse settlements, particularly isolated or scattered examples was, however, very uneven. Many sites had no discernible features that could be digitised, compromising statistical analysis of the polygonal dataset.

Unlike the transcription process, the creation of the research categorisation dataset did not follow established approaches to digitisation. As outlined in the methodology (chapter 4), it involved the creation of a separate and documented workflow for categorising features as monuments, with new

[53] Whilst every effort was made to cross-reference the dataset with existing records, inaccurate and/or imprecise grid references and record duplication made this task difficult at times and there will inevitably be some errors and omissions.

attribute fields designed to help inform the project research questions. Separating 'form' from 'type' in this way focused attention on the following important areas:

(1) *Assessing temporality*

The categorisation of monuments included attributing specific, narrow or broad dates to features, depending on the evidence, with the intention of capturing their date more accurately. The attribute data for 'dating type' provided more detailed information about the basis for dating and a guide to confidence and reliability.

(2) *The process of early enclosure*

Separating site or monument 'type' (research categorisation dataset) from surviving 'form' (the transcription dataset) emphasised the interpretative gap between recognising a feature and understanding its relevance to the process of enclosure.

These themes are explored further in the preliminary analysis of the research categorisation dataset discussed below.

(1) Assessing temporality

The creation of new attribute fields for 'period' and 'dating type' relied on detailed re-examination of existing national and regional records. The distribution of records shows that they are present for the majority (80%) of features for most site types, but not for the largest numerical feature types: early field boundaries, early settlement remains, clearance cairns and areas of ridge and furrow cultivation (*Figure 5.35*). Attributing values for the period and dating type field involved assessing relevant records and referenced material, including original unpublished and published reports for surveys, field visits and excavations. There was variation between regional and national period attribution and although many sites are recorded as belonging to a single period, additional narrative-based information often refer to continued settlement occupation or uncertainty about dating.

Attributing broader time periods to features demonstrates their potential chronological overlap in their formation and use. The creation of a new 'dating type' field added greater clarity by allowing this important attribute to be quantified and compared across the dataset. Confirming observations by Johnston (2008b) and others, it showed that a very small percentage of sites within or close to the study area have reliable chronologies in the form of radiocarbon dates, excavated finds or direct stratigraphic evidence. Not all of these sites can be tied directly to digitised features in the research categorisation dataset and they often date only one or two phases in their life history.

Five transcribed features can be related to radiocarbon dated contexts: Cefn Coch ring cairn[54] (Callow et al. 1963, Griffiths 1962), Graianog East settlement[55] (Mason et al. 1998), Crawcwellt iron-working settlement (Crew 1983c, Crew 1989, Crew 1998), Dinas Emyrs hillfort[56] (Williams and Johnson 1976) and Caer Seion hillfort[57] (Smith 2009). Except for the last of these, which involved the reinvestigation of excavation trenches from the 1950s, all were from bulk charcoal samples taken more than 35 years ago. These dates are effectively useless by modern standards and there is, therefore, only one scientifically dated site that corresponds to a transcribed feature.

More broadly, excavation has concentrated on roundhouses, representing more than half the 55 investigations in the study area, with these examples variously attributed to prehistoric[58], Roman[59], early medieval[60] and medieval[61] dates (*Figure 5.36*). As with the radiocarbon samples, most of this work took place decades ago: the earliest example was investigated in the 1860s by Owen (1872). Comparison between the excavation plans and earthworks visible on the lidar model suggest further damage to the original enclosed settlement group (*Figure 5.37*).

Attributing unexcavated roundhouses in the research categorisation dataset to a late prehistoric to early medieval date is based primarily on analogy with excavated sites: roughly speaking, this meant similarity in plan form between round structures with a diameter of between 5m and 15m, and walls varying in width between about 1m and 3m. Context was also important and further details about the character, location and association with other early features were recorded for many sites by previous fieldworkers: more than three quarters of the digitised roundhouses have a record in the regional or national records (79%) which was consulted as part of the digitisation process (*Figure 5.33*, *Figure 5.38* and *Figure 5.39*). It should be emphasised, however, that of the almost 950 *point-data* HER records in the study area with a site type described as 'hut circle', 'hut circle settlement', 'hut' or 'hut platform', less than a fifth (17%) were directly related to features recognised on lidar models (*Figure 5.39*), either because they could not be identified on the lidar or because of patchy lidar coverage. The absence of so many sites from the early fieldscapes polygonal dataset had a major impact on the potential for more detailed spatial analysis.

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[54] PRN 542, NPRN 300946, Scheduled Monument CN024
[55] PRN 117, GD67 (Waddington 2013)
[56] PRN 1462, NPRN 95284, Scheduled Monument CN018, GD16 (Waddington 2013)
[57] PRN 2816, NPRN 95279, Scheduled Monument CN012, AB5 (Waddington 2013)
[58] PRN 214, 294, 322
[59] PRN 27, PRN 108, PRN 109, PRN 594, PRN 629, PRN 2374
[60] PRN 717
[61] PRN 320

Many of the roundhouses were associated with enclosures, but within this group of features a smaller percentage of sites was recorded in national or regional records (only 64%). New discoveries were typically identified in small areas of woodland, scrubby field edges or corners, and on uncultivated ground. Notable examples include a concentration of circular enclosures to the north of Llanllechid, all within a few hundred metres of one another, two of which were associated with probable roundhouses (*Figure 5.41*). Only one site had been previously recognised and is scheduled[62].

Half of all the enclosures have been broadly dated, most by association with roundhouses, from the prehistoric to early medieval period. They typically enclose an area of about 0.14 hectares, though irregular examples are more difficult to identify and measure. There was no significant difference in shape or size between those with and those without evidence for roundhouses. An unusual concentration of six enclosures survive within a few kilometres of the hillfort at Dinas Dinlle, to the south of Caernarfon, and may be later in date. The enclosures have evidence for additional outer banks, typically twice the diameter of the inner circle. Following convention, these features have been categorised as defended enclosures, and their total area is larger than the average for all enclosures in the study area (including the outer bank 0.37 hectares, excluding it 0.08 hectares). None of the examples in this group have evidence for associated roundhouses and three are newly recognised[63] (*Figure 5.40*). One of the sites, Hen Castell in Llanwnda[64], has been recently excavated (Kenney et al. 2017). Radiocarbon dates demonstrated occupation of the site during the eleventh and twelfth centuries AD. The excavation followed many years of survey and study focused on prehistoric defended enclosures in northwest Wales (Smith 2003, Smith 2005, Smith 2006, Smith and Hopewell 2007b, Hopewell et al. 2008, Smith 2008). The radiocarbon results were unexpected, highlighting the possibility that other defended sites may also be medieval in date.

Other site types with a large proportion of features dated by analogy are long houses, and areas of ridge and furrow cultivation, often identified in close proximity to one another and provisionally dated to the early medieval or medieval periods. The majority of hillforts have also been dated by analogy; less than a fifth have associated, potentially diagnostic finds, and only one example has a radiocarbon date. Their size and prominence, however, mean that their distribution is better understood and studied. Comparison between examples included in the regional and national records and the early fieldscape dataset show that three-quarters lie within areas with lidar coverage. Most of these have some features that are visible on lidar models and are, therefore,

[62] PRN 295, Rhiw Coch Camp Scheduled Monument CN056
[63] One was previously identified only as a circular cropmark feature on aerial photographs, PRN 5351
[64] PRN 584

included in the dataset. However, a quarter lie outside areas with lidar coverage. Although the effect is less pronounced than the roundhouse data subset, partial digitisation of this important group of monuments has limited the scope for detailed analysis using geospatial and geostatistical techniques.

A fifth of all records have been dated by association because they have no direct or analogous evidence. In most cases, these are areas that have been surveyed, either as part of this study or by previous fieldworkers, and relationships between features observed on the ground and through the analysis of lidar models. The majority of the roughly 7,000 'undated' features where there is no evidence are also located close to dated sites. Many of these may also be pre-medieval in date, but a cautious approach was adopted during the categorisation process, given the already high levels of uncertainty around dating.

Two ploughed-out boundaries on the coastal lowlands north of Llanfairfechan have been tentatively dated as pre-Roman based on their stratigraphic relationship to a possible Roman road (*Figure 5.42*). No other convincing examples for stratigraphic dating were identified during the transcription process, in spite of an extensive and well-researched network of routes between Roman forts (Hopewell 2004, Hopewell 2007).

(2) The process of early enclosure

Broadening the chronological span over which early enclosure potentially took place has implications for the study of monuments conventionally identified as dating to the second millennium BC. The most significant group are Bronze Age burial cairns, and burnt stone mounds dated from the late Neolithic to medieval period (Kenney 2012a, Johnston 2021). The similarity between some of these monuments and others, such as clearance cairns, illustrates the interpretative value of separating 'form' (the transcription dataset) from site or monument 'type' (research categorisation dataset).

Mounds are distributed across the study area, but only half have been categorised, with the highest concentration of uncategorised examples along the north coast (*Figure 5.43*). The descriptive monument 'types' used here follow existing terminology[65] (as discussed in chapter 4), and include burial cairns, clearance cairns, long cairns, burnt mounds, barrows, cairnfields and cairns. They have been identified on the basis of previous survey or association with early fields, as demonstrated by the correlation between the total number of features and point-data records (*Figure 5.44*). This

[65] https://heritagedata.org/live/schemes/10/concepts/68543.html

subset of records required careful analysis of original regional and national records to assess how to categorise features, given the varied use of terms and dating.

Larger, usually isolated examples, and those with documented evidence for kerb stones and cists have been identified as 'burial cairns', based on analogy with excavated examples, and they have all been attributed to the Bronze Age. Their median diameter is 11m, with the largest examples reaching 30m across. A slightly larger number of 'cairns' (a total of 54) include examples where there is no evidence for burials or convincing dating evidence, though many are similar in size and character to the burial cairn group.

Cairns associated with small, irregular fields have been identified as 'clearance cairns', particularly if they are located at the centre of fields or distributed evenly across the enclosed area. Most are provisionally dated by association to the late prehistoric to early medieval periods, except where they appear to be associated with medieval ridge and furrow cultivation, but more than half are not dated. Three concentrations of relatively small cairns have been described by previous fieldworkers as 'cairn cemeteries' or 'cairnfields', on the uplands above Dyffryn Ardudwy[66], Abergwynant[67] and above Llanfairfechan[68], however, there are similar clusters elsewhere, such as Abergwyngregryn[69] (Garreg Fawr).

Burnt mounds have been identified in small numbers across the study area, with one excavated example at Waun Llanfair[70] (Caseldine et al. 2007) and three others where burnt stone or a trough was observed during field work[71] (Hopewell and Smith 2010). The remaining 19 have been identified on the basis of their distinctive crescent shape and their categorisation is, therefore, provisional.

The interpretative value of separating 'form' (the transcription dataset) from site or monument 'type' (research categorisation dataset) proved valuable for a second feature subset: roads and routeways. Roman roads have been studied in detail (Hopewell 2004, Hopewell 2007) and within the study area there are a small number of short sections which have been identified on lidar models, usually as single banks. In some cases, surviving ditches and hollows have been identified: for example, a short stretch close to Pentir[72] has several hollows adjacent to the road which are likely to

[66] PRN 5162, NPRN 58215
[67] PRN 12883
[68] PRN 495
[69] NPRN 278513
[70] PRN 467, NPRN 303027
[71] PRN 200, PRN 4163, PRN 60770
[72] PRN 17834

be the remains of quarry pits used during its construction (John Griffith Roberts pers. communication).

Double-walled banked routeways form a larger group, all but one of which newly recognised, and are predominantly associated with or leading to roundhouse settlements. As noted previously, they show up best on open-positive or sky-view factor lidar models where detailed features are clearest. Scheduled monuments, such as the large area east of Llanllechid[73], where feature preservation is good, have the best evidence for routeways on 1m resolution lidar. More are likely to be recognised with higher resolution lidar models, which will make it easier to distinguish them from what appear to be wider banks.

Concluding comments

The descriptive statistics presented in this chapter show that the process of digitising features from 1m resolution lidar models dramatically increased the number, extent and distribution of early fieldscapes. Most newly identified features were either linear earthwork banks or mounds. The consistent use of different lidar models generated using the Relief Visualisation Toolbox (RVT) increased the recognition of many feature types. Simple local relief models (SLRM) were particularly good for identifying ploughed out boundaries in areas where no evidence for enclosure had been previously recognised. Open-positive lidar models showed smaller or detailed sites such as roundhouses, routeways and paths most clearly, often in areas of known early fields.

Creating a separate workflow to categorise features as 'monuments' focused attention on the process of interpretation and dating. It highlighted the reliance on morphology and typology, expanding the scope to revise and refine current understandings for the chronological context for enclosure. A significant proportion of features could not be confidently attributed to a 'type'. These were primarily boundaries, usually where the transcription lacked accuracy or detail because of poor quality lidar models, or where features were obscured by more recent sheepfolds and buildings. More than half the mounds could not be categorised as monuments.

Comparison between the research categorisation dataset, national (National Monument Records) and regional point data records (Historic Environment Record) demonstrates that the existing records have a strong bias towards individual monuments. However, many roundhouse settlements, particularly isolated or scattered examples, were not visible on the lidar models. This is almost certainly due to their size rather than preservation, and transcription from higher resolution lidar models would help address this gap in the early fieldscapes dataset. No spatial extent could be

[73] 'Early Fields and Dwellings East of Llanllechid', Scheduled Monument CN121

digitised for a quarter of all known hillforts because they were located in areas without lidar coverage, and it must be assumed that similar bias will have affected less well-known features.

Dating was difficult. Beyond identifying features as 'early' because they did not appear on 1st edition Ordnance Survey maps (or later sources), dating relied on analogy and the association with other sites or features such as roundhouses. Most monuments were attributed to a span of roughly two thousand years, from the late prehistoric to early medieval period. Using broad time periods underlined the interpretative difficulties, but also highlighted their potential longevity and the likelihood that they were created and actively used over a long period of time.

Table 5.1
Summary of transcribed features

Dataset	Area (hectares)	Number of records
Original study area	53,132	1
Lidar coverage, 1m resolution	22,636	Multiple (composite dataset)
Study area	141,886	1
Lidar coverage, 1m resolution	99,394	Multiple (composite dataset)

Table 5.2
Transcription dataset (feature subtype)

Label	Description	Number of individual features	Mean feature area (square metres)
Bank	Narrow earth bank or earth covered stone wall	7,440	169
Flattened wide bank	Flattened earth bank or earth covered stone wall	2,501	618
Lynchet	Wide earth terrace or ridge on slope	840	377
Scree bank	Bank with extensive surface stone visible	11	-
Ditch	Linear ditch	102	193
Wall	Stone wall	46	-
Structure	Stone structure	2	-
Pit	A hole or cavity in the ground	14	10
Mound	Circular or irregular (non-linear) earthwork	2,494	33
Hollow	Circular or irregular (non-linear) cut feature	90	287
Cultivation ridges	Extent of linear earthworks associated with cultivation	259	2,675
Not known (or null)	Feature not identified as positive, negative, linear or irregular form (or discounted)	105	-
	Total	13,904	-

Table 5.3

Research Categorisation dataset (feature subtype)

Label	Original dataset label	Number of individual features	Number of *undated* individual features	Number of *dated* individual features by: Radiocarbon date	Morphological analogy with dated site	Finds, excavation or stratigraphic relationship to dated site	Morphological association with dated site
Prehistoric funerary and ritual monuments	Barrow	4	0	0	1	3	0
	Burial cairn	21	0	0	15	1	4
	Long cairn	1	0	0	1	0	0
	Chambered tomb	3	0	0	1	2	0
	Stone circle	4	0	1	2	1	0
Early field boundaries	Early field boundary	7,302	5,923	0	2	3	1,242
Early cultivation terraces	Early cultivation terrace	172	115	0	1	0	56
Enclosures	Enclosure	240	141	0	34	11	89
	Defended enclosure	15	0	0	12	0	0
Hillforts	Hillfort	28	0	1	20	5	1
Forts	Fort	2	0	0	1	1	0
Roundhouse settlement remains	Roundhouse	268	0	0	230	18	18
	Roundhouse settlement remains	161	0	0	127	5	29
Early settlement remains	Early settlement remains	452	27	4	247	10	166
Roads and routeways	Road	21	8	0	1	0	11
	Routeway	35	22	0	0	0	13
Long houses	Long house	45	0	0	43	0	2
Ridge and furrow	Ridge and furrow	241	4	0	236	0	0
Burnt mounds	Burnt stone mound	23	3	0	16	1	2
Clearance cairns	Clearance cairn	1,081	658	0	0	0	422

Cairnfield	Cairnfield	80	0	0	0	0	80
Cairn	Cairn	54	37	0	13	0	4
	Sub-totals	10,253	6,938	6	1,003	61	2,139

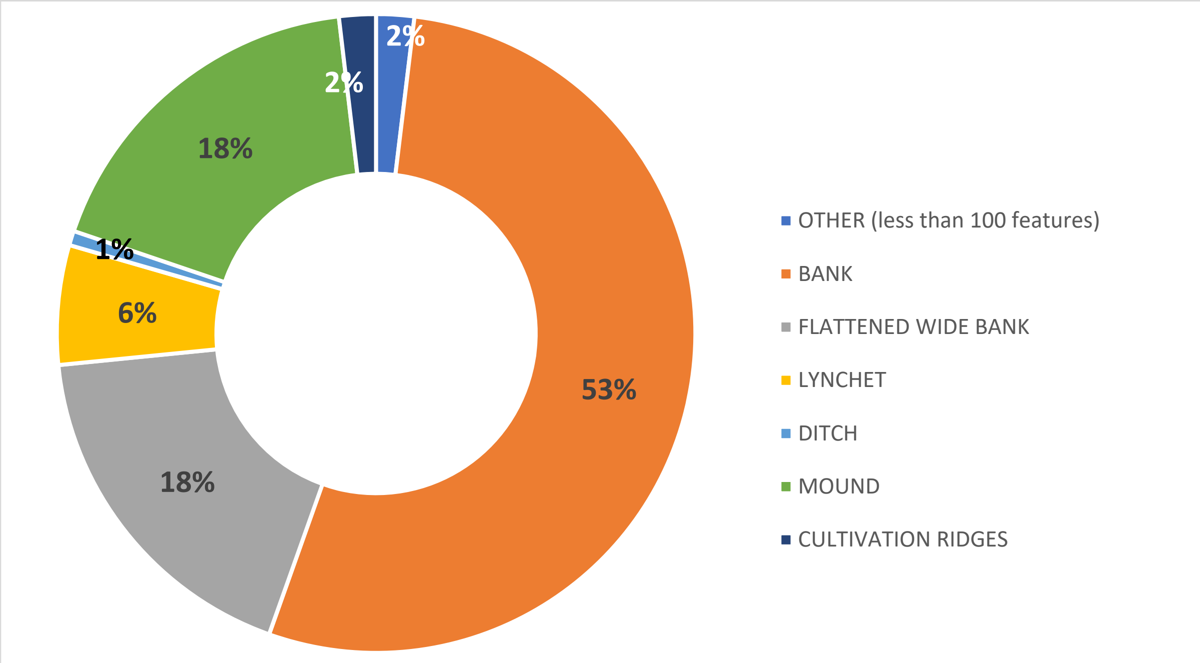


Figure 5.1
Archaeological feature type (N=13904)

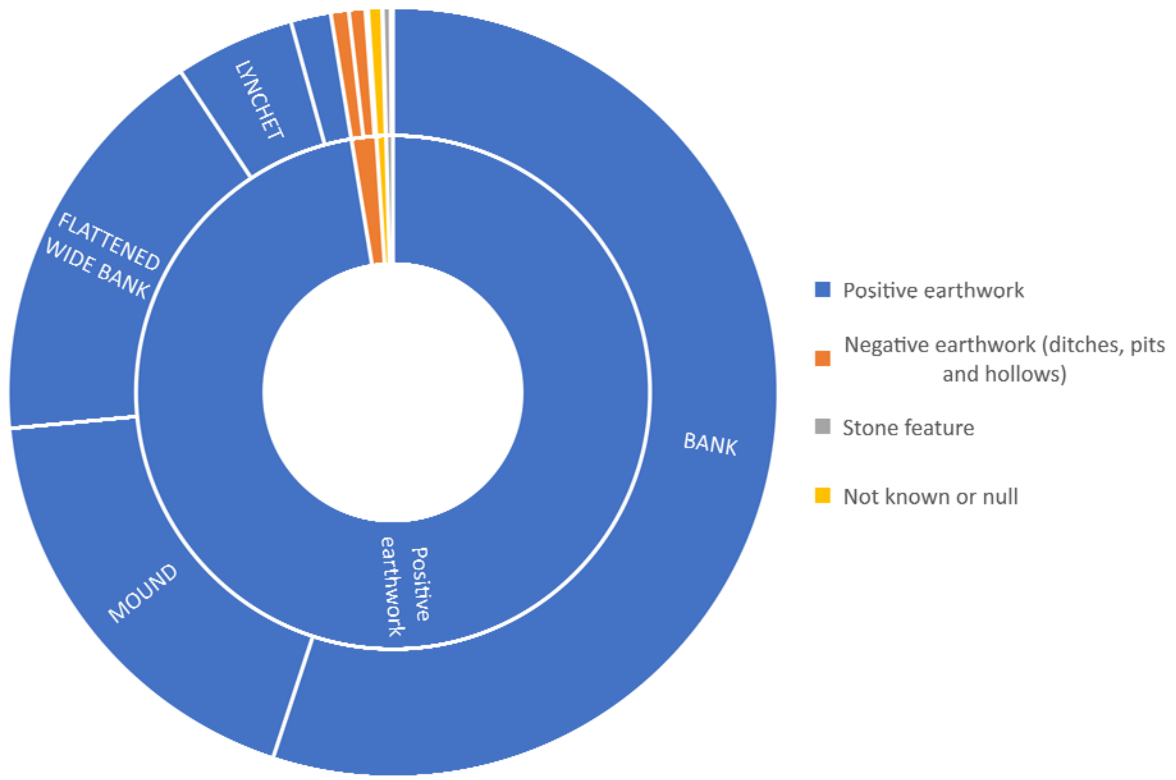


Figure 5.2
Archaeological feature form and type (N=13904)

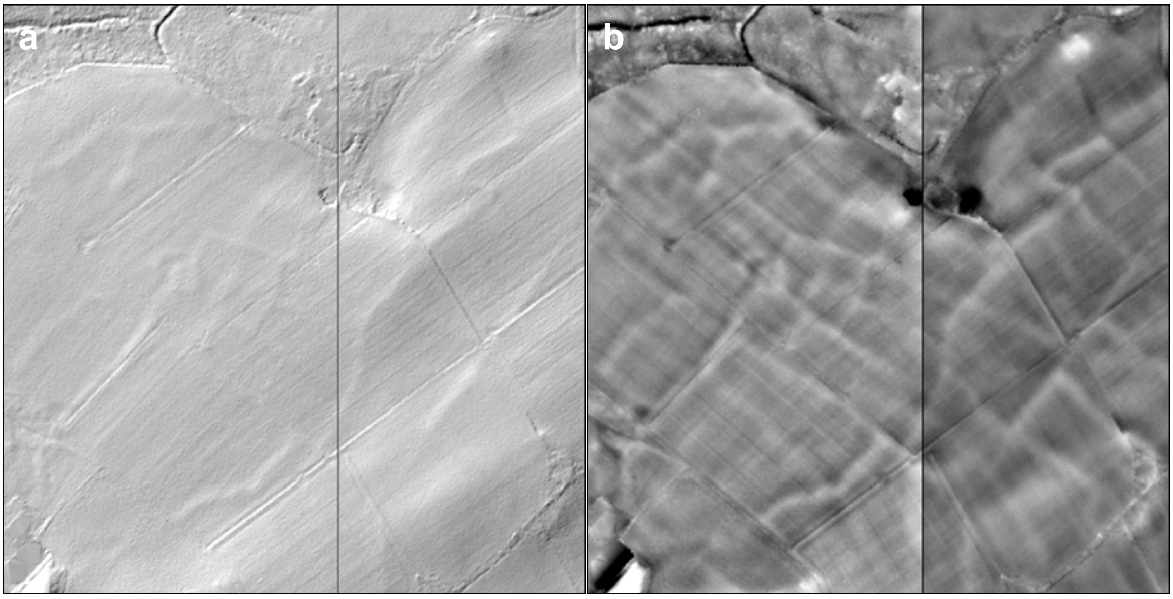


Figure 5.3
Early field boundaries preserved in fields between Pentir and Caerhun, shown at 1:7,500

Comparison between hillshade model (a) and simple local relief model (SLRM) (b) illustrate the value of SLRM visualisations which reveal much more detail about the original layout of boundaries.

See Appendix K, transcription map 1 for context
Centred on grid reference: 25700 36830

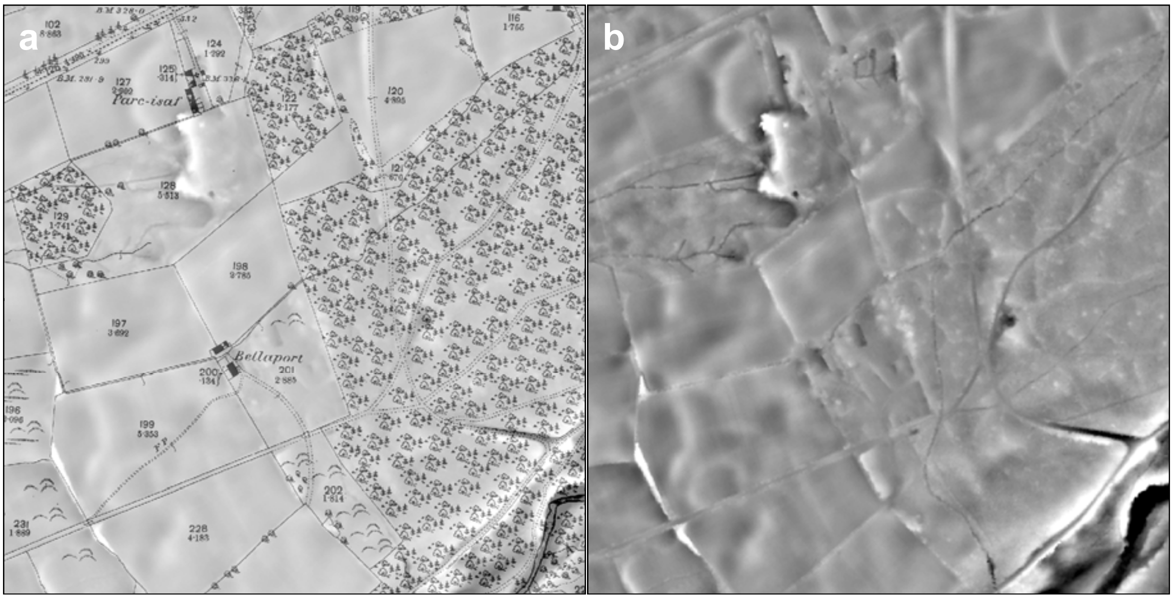


Figure 5.4
Features on the coastal lowlands at Cors y Gedol, Ardudwy, shown at 1:7,500

Comparison between the 1st edition Ordnance Survey map (1885-87) (a) and simple local relief model (b) shows field boundaries, clearance cairns and enclosures in woodland (on the right) that survive as ploughed out features in improved fields on the lower slopes (to the left).

See Appendix K, transcription map 19 for context
Centred on grid reference: 25950 32240

1:2500 County Series 1st edition [TIFF geospatial data], Scale 1:2500, Tiles: meri-sh5922. Updated 30 November 2010, Historic, Using EDINA Historic Digimap Service, <http://digimap.edina.ac.uk>, Downloaded: 2018-02-02 15:25:56.039 © Crown Copyright and Landmark Information Group Limited (2020). All rights reserved. Contains Natural Resources Wales information © Natural Resources Wales and database right.

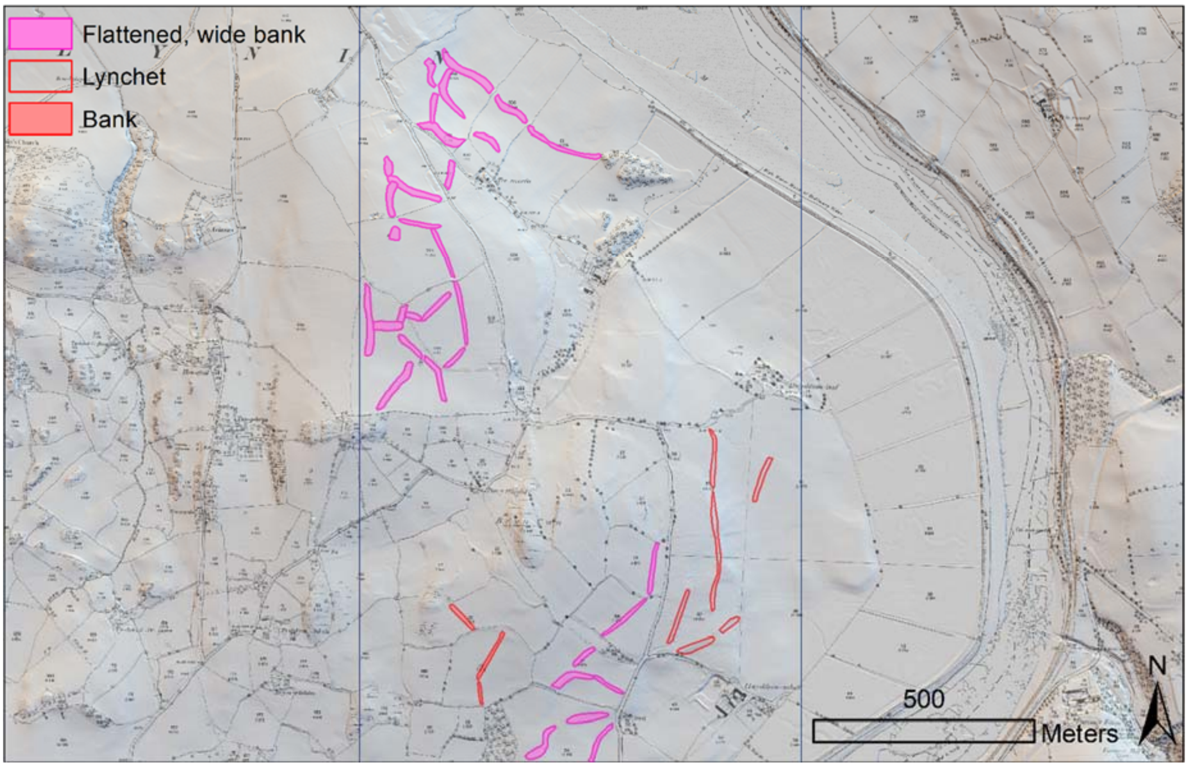


Figure 5.5
Field boundaries on the western banks of the Afon Conwy, Dyffryn Conwy, shown at 1:15,000

Transcribed features overlain on the 1st edition Ordnance Survey map (1885-87) and multi-hillshade lidar visualisation show previously unrecognised ploughed-out and flattened wide banks underlying nineteenth century field boundaries

See Appendix K, transcription map 3 for context
Centred on grid reference: 27850 37300

1:2500 County Series 1st edition [TIFF geospatial data], Scale 1:2500, Tiles: caer-sh7771, caer-sh7772, caer-sh7773, caer-sh7871, caer-sh7872, caer-sh7873, caer-sh7971, caer-sh7972, caer-sh7973. Updated 30 November 2010, Historic, Using EDINA Historic Digimap Service, <http://digimap.edina.ac.uk>, Downloaded: 2018-02-02 15:25:56.039 © Crown Copyright and Landmark Information Group Limited (2020). All rights reserved. Contains Natural Resources Wales information © Natural Resources Wales and database right.

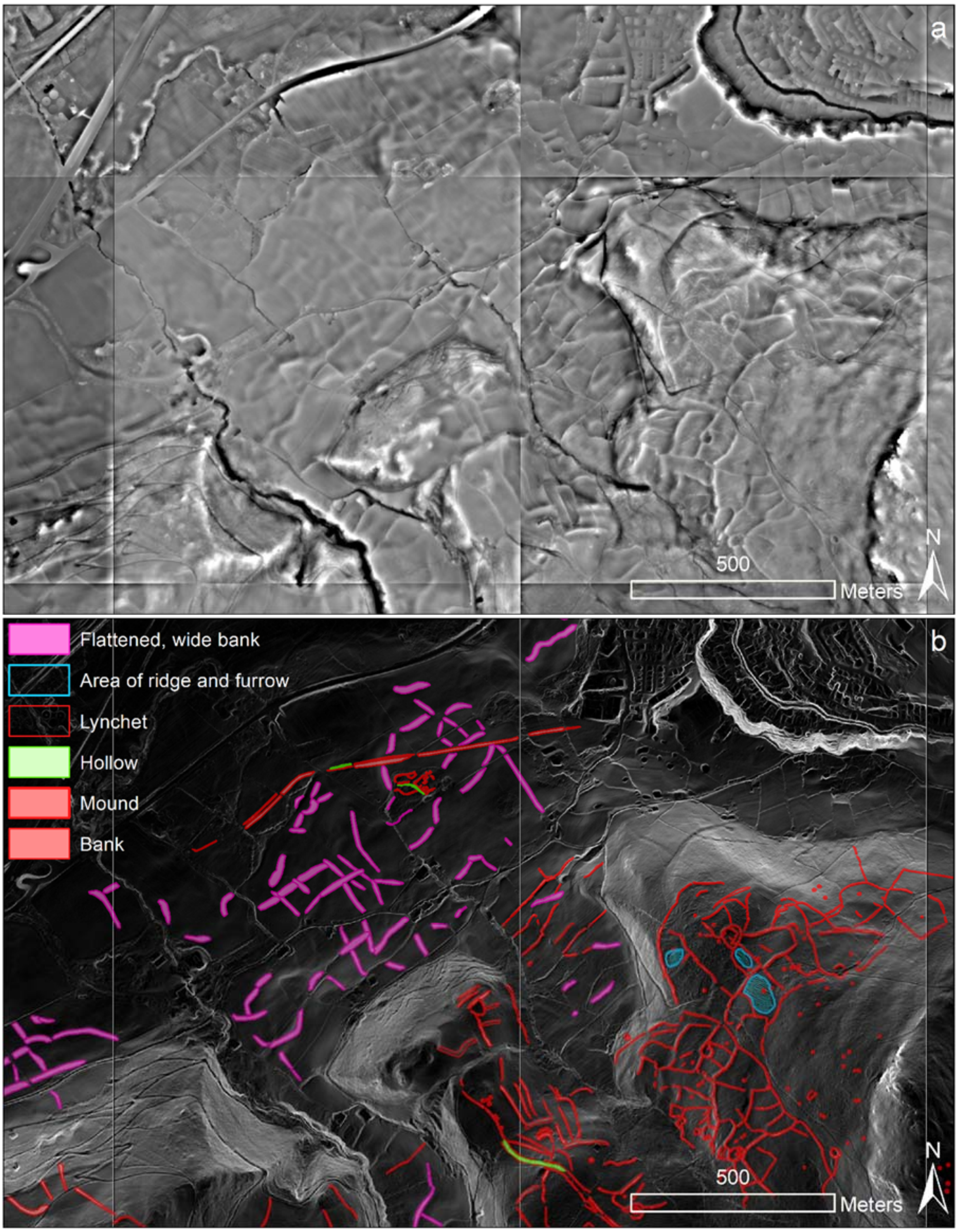


Figure 5.6
Coastal strip between Abergwyngregyn and Llanfairfechan, shown at 1:15,000

Comparison between simple local relief lidar model (a) and SLOPE lidar model overlain with the transcription dataset (b) shows area of flattened, wide banks surviving on lower lying land.

See Appendix K, transcription map 2 for context
Centred on grid reference: 26790 37370

Figure 5.7
Glynllifon Estate, shown at 1:7,500

Transcribed features overlaid on the 1st edition Ordnance Survey map (1885-87) and simple local relief lidar visualisation illustrate the survival of boundaries in most of the open parkland and improved fields (see overleaf for further map details)

See Appendix K, transcription map 9 for context
Centred on grid reference: 24570 35480

1:2500 County Series 1st edition [TIFF geospatial data], Scale 1:2500, Tiles: caer-sh4456, caer-sh4556, caer-sh4656, caer-sh4455, caer-sh4555, caer-sh4655, caer-sh4454, caer-sh4554, caer-sh4654, caer-sh4453, caer-sh4553, caer-sh4653. Updated 30 November 2010, Historic, Using EDINA Historic Digimap Service, <http://digimap.edina.ac.uk>, Downloaded: 2018-02-02 15:25:56.039

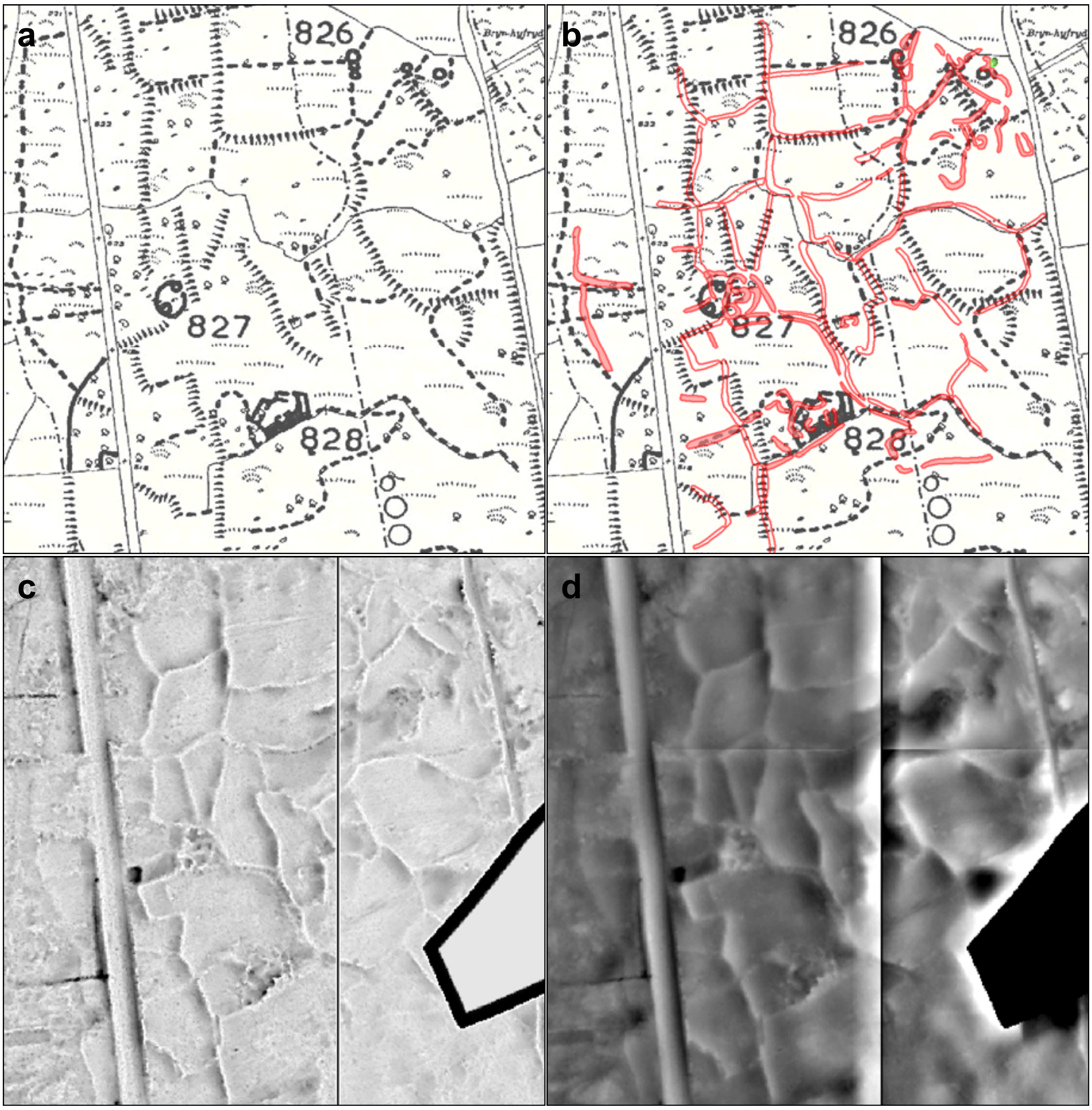


Figure 5.8
Caerau, Pant Glas (Bryncir), shown at 1:7,500

Comparison between survey carried out in 1947 by the RCAHMW (1960: figure 42) (a) and features transcribed (b) from open-positive lidar model (c) which has better resolution for detailed features than the simple local relief model (d).

See Appendix K, transcription map 9 for context
Centred on grid reference: 24690 24890

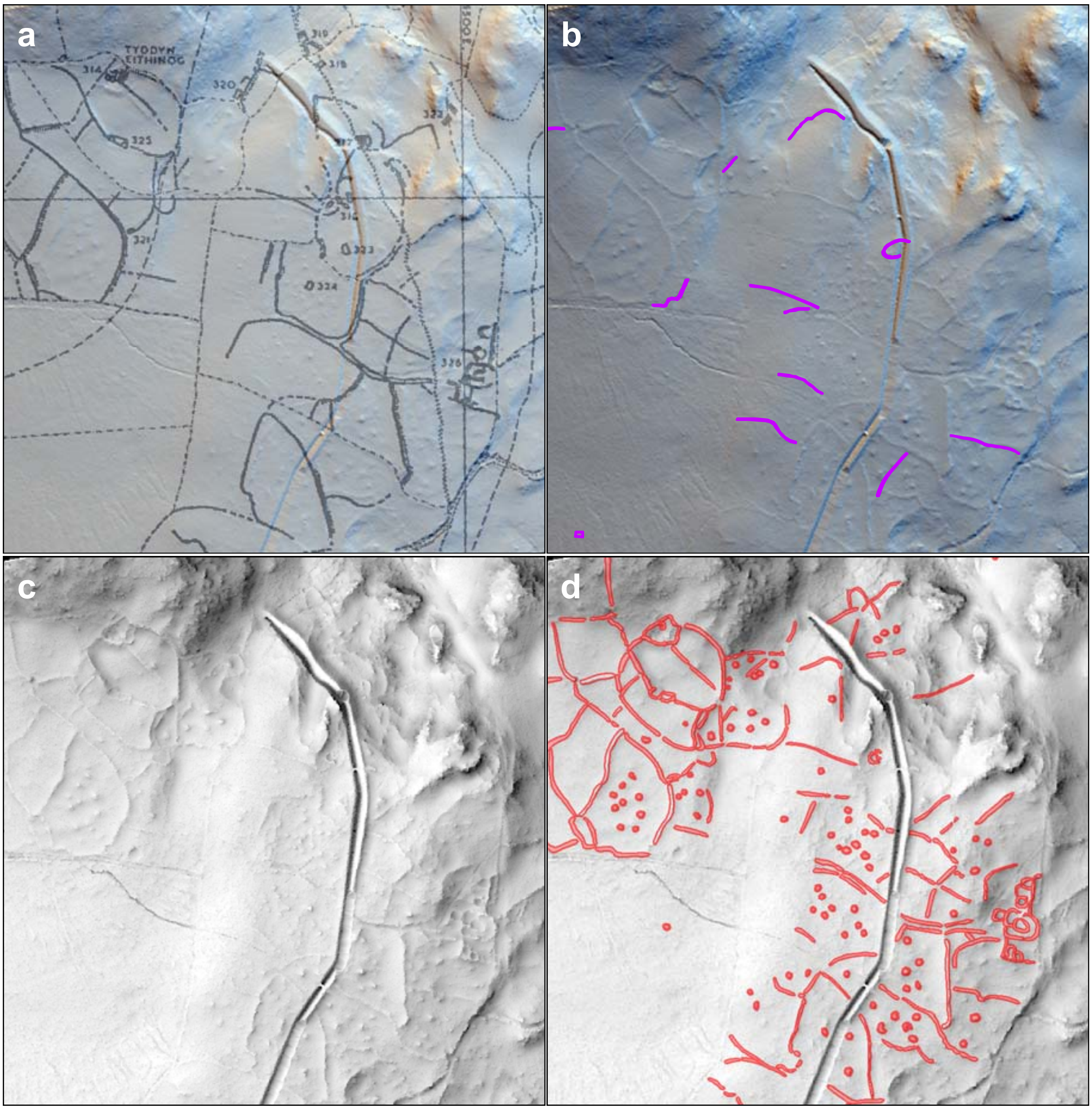


Figure 5.9
Pen-y-gaer, Llanbedr y Cennin (Conwy Valley), shown at 1:7,500

Comparison between survey carried out in 1951 by the RCAHMW (1960: figure 101)(a) and features transcribed from RAF vertical photographs in 2004 (b), both overlain on multi-hillshade lidar models, with sky-view factor (SVF) lidar model shown overlain with transcribed features, including almost 100 cairns (c, d).

See Appendix K, transcription map 3 for context
Centred on grid reference: 27530 36890

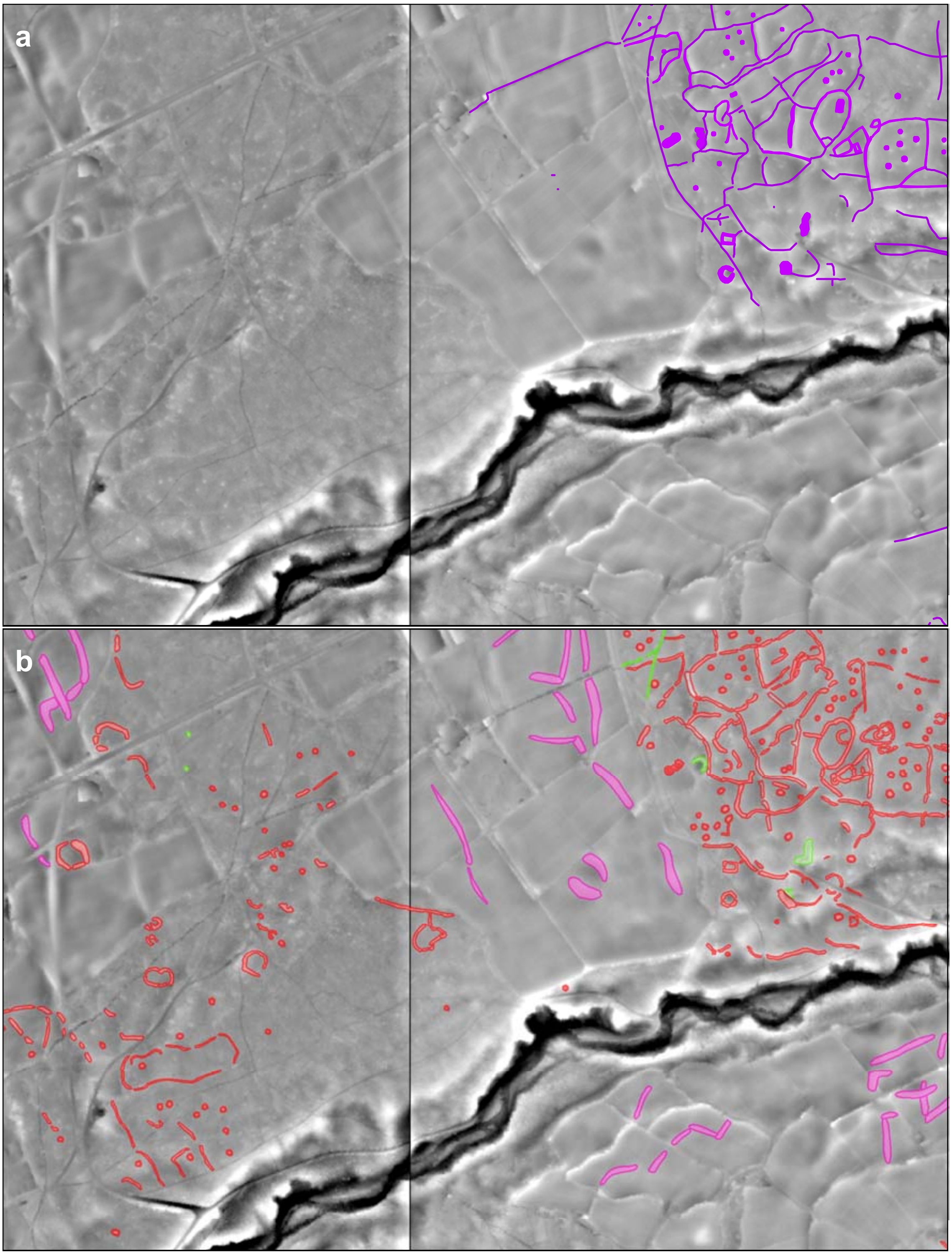


Figure 5.10
Cors y Gedol, Dyffryn Ardudwy, shown at 1:7,500

Comparison between transcription from vertical photographs (a) and lidar models (b), both overlain on simple local relief model, showing early fieldscape features extending over a larger area.

See Appendix K, transcription map 19 for context
Centred on grid reference: 26020 32270

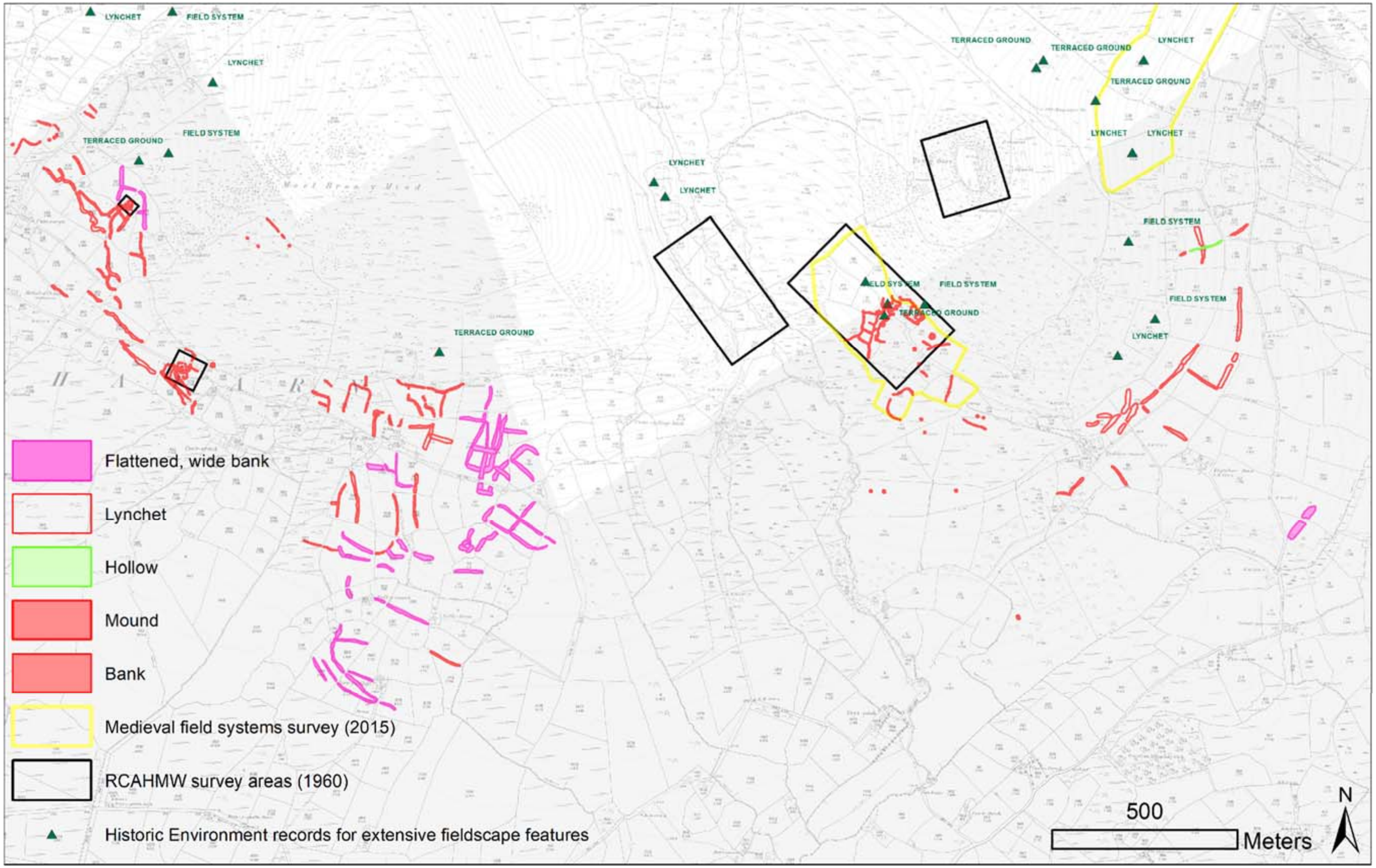


Figure 5.11
Llanaelhearn, slopes below Moel Bronmiod and Pen-y-Gaer, Pen Llŷn, shown at 1:15,000

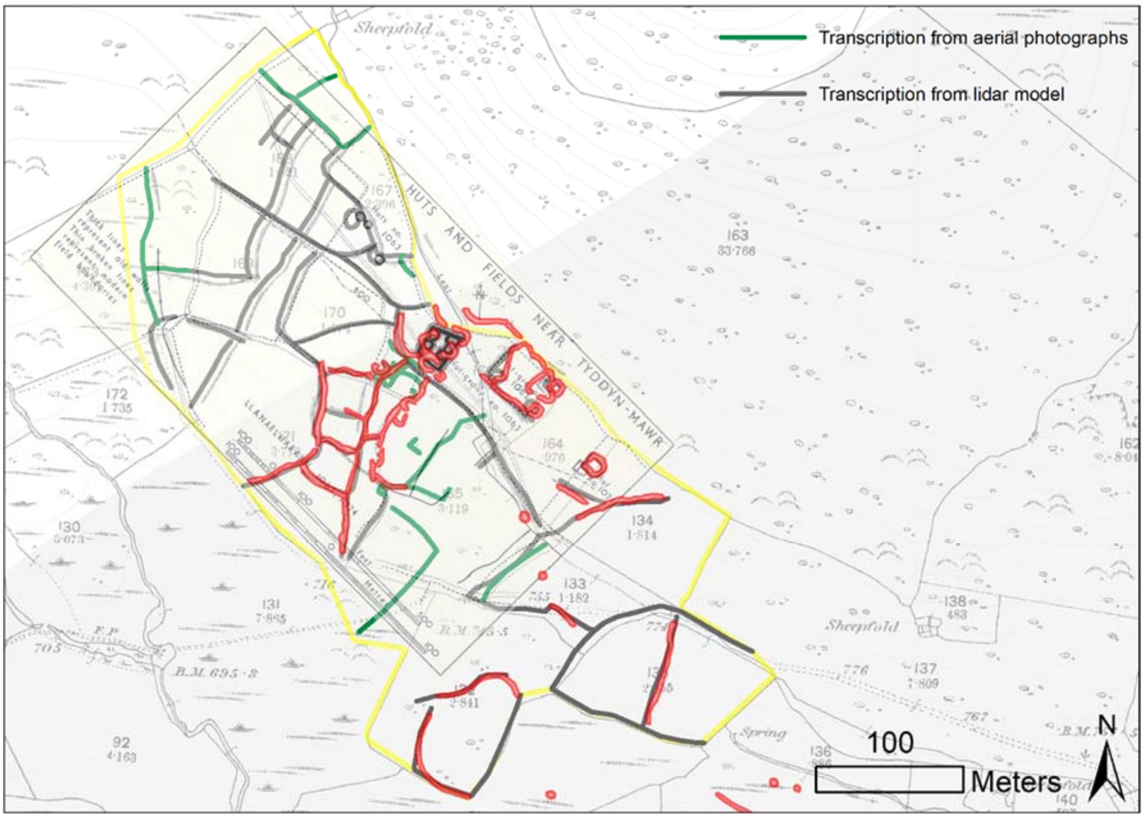


Figure 5.12
Llanaelhearn, slopes below Moel Bronmiod and Pen-y-gaer, shown at 1:5,000

Inset map for area surveyed by RCAHMW (1960) and studied by Kenney (2015), overlaid on 1st edition Ordnance Survey map (1885-87). The grey and green polylines are transcribed by Kenney; red polygonal extents are transcribed as part of the early fieldscapes dataset.

See Appendix K, transcription map 13 for context
Centred on grid reference: 24260 34500

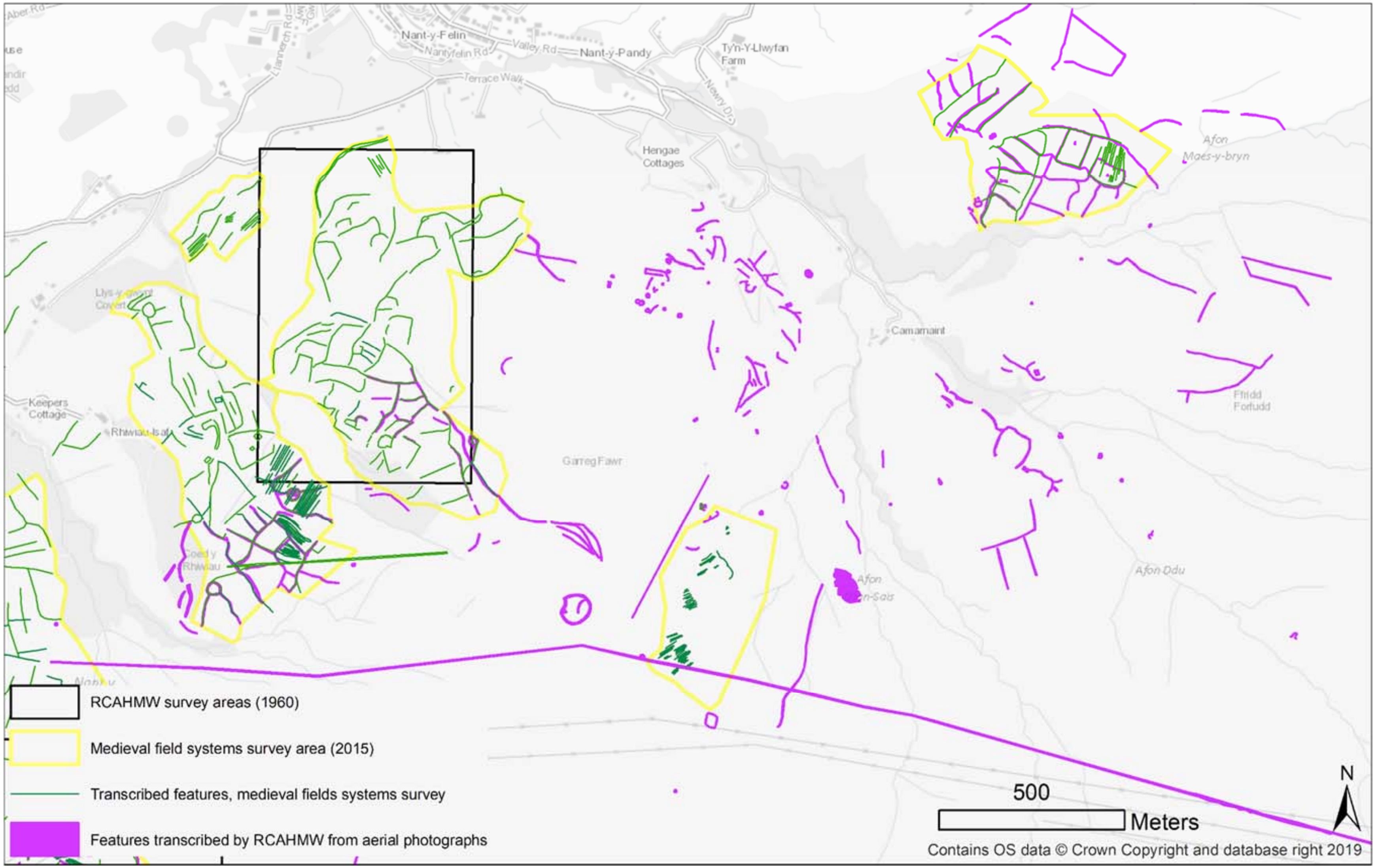


Figure 5.13
Previous survey work in the uplands above Llanfairfechan, shown at 1:15,000

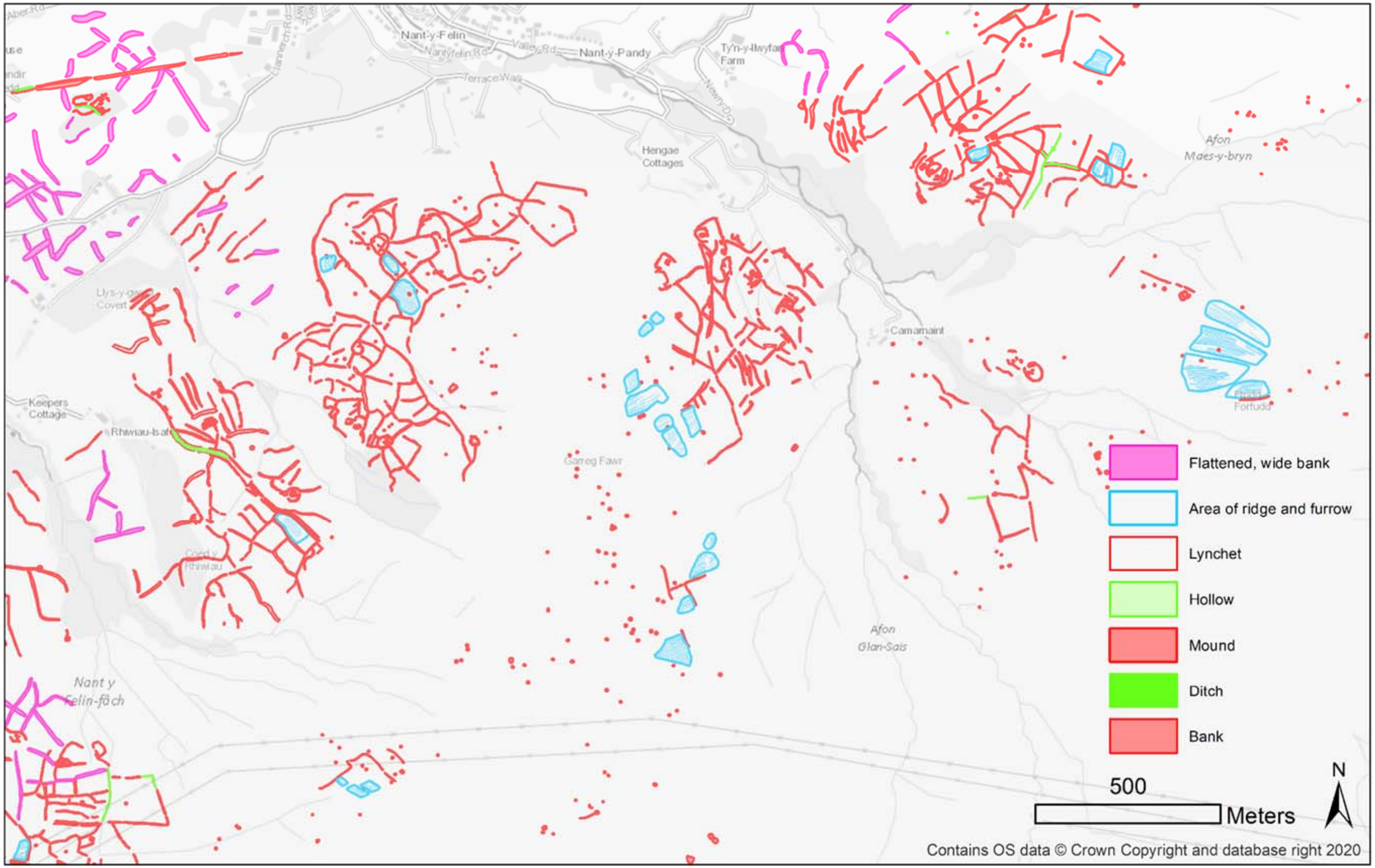


Figure 5.14
Early fieldscapes transcription of features in the uplands above Llanfairfechan (same map extent as figure 5.13 above), shown at 1:15,000

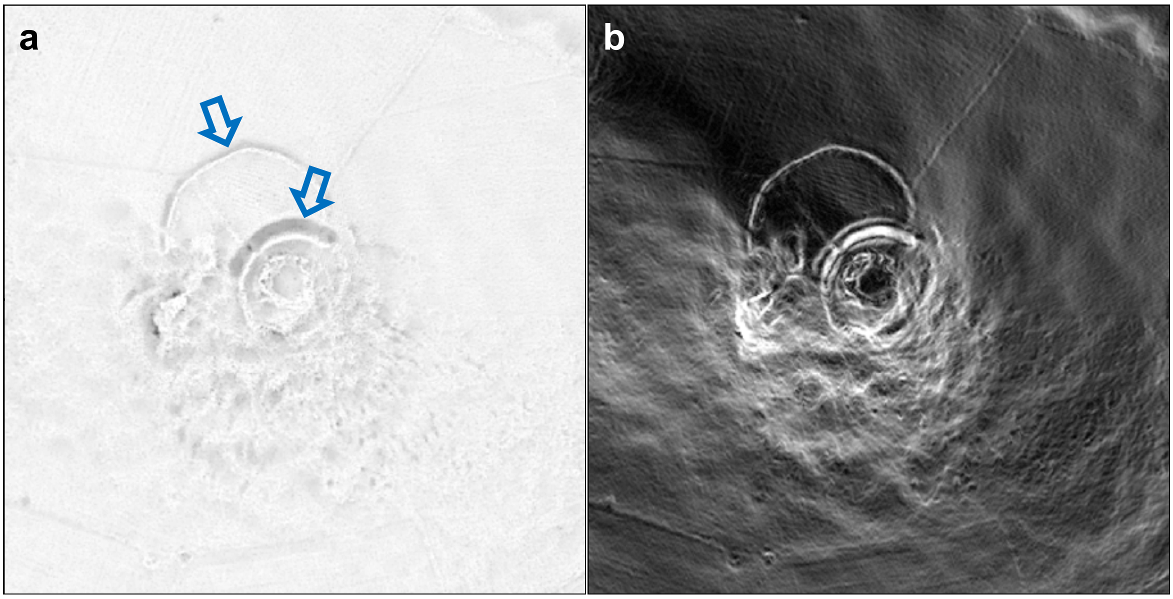


Figure 5.15
Carn Pentryrch hillfort, north of Llangybi, Pen Llŷn, shown at 1:5,000

Open-positive lidar model (a) and SLOPE lidar model (b) showing ditch features clearly (indicated by blue arrows).

See Appendix K, transcription map 13 for context
Centred on grid reference: 24240 34170

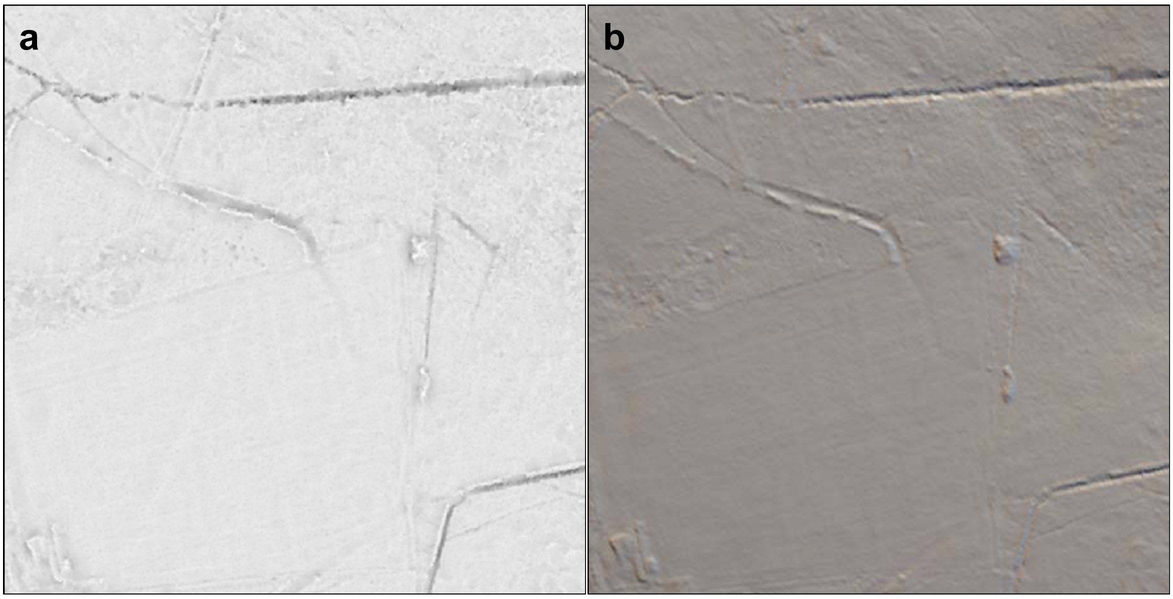


Figure 5.16
Hollow way to the north of Cors y Gedol, Dyffryn Ardudwy, shown at 1:5,000

Open-positive lidar model (a) and SLOPE lidar model (b) showing hollow way continuing into the field to the south.

See Appendix K, transcription map 19 for context
Centred on grid reference: 26035 32335

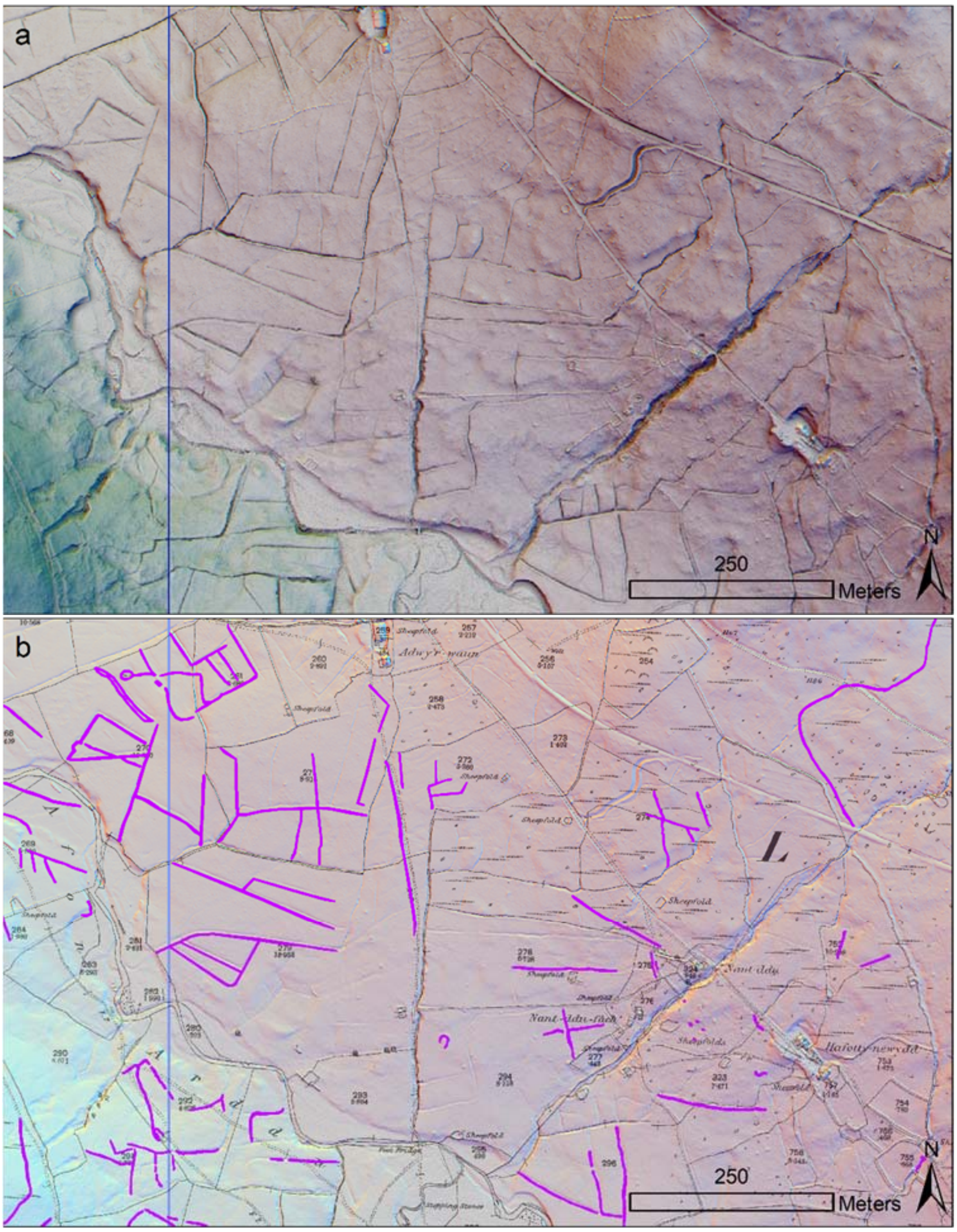


Figure 5.17
Slopes to the south-east of Moel Eilio, shown at 1:7,500

Multi-hillshade lidar model overlain on sky-view factor (SVF) lidar model (a) overlain by 1st edition Ordnance Survey map (1885-87) and transcription from aerial photographs by RCAHMW in 2007 (b). The multi-hillshade lidar model is processed from a digital surface model (DSM), depicting stone walls close to Nant-ddu farm and Hafotty-newydd farms. Work by the RCAHMW illustrates the difficulties transcribing features consistently; the attribute data records ditches, trackways and walls.

See Appendix K, transcription map 6 for context
Centred on grid reference: 25835 35790

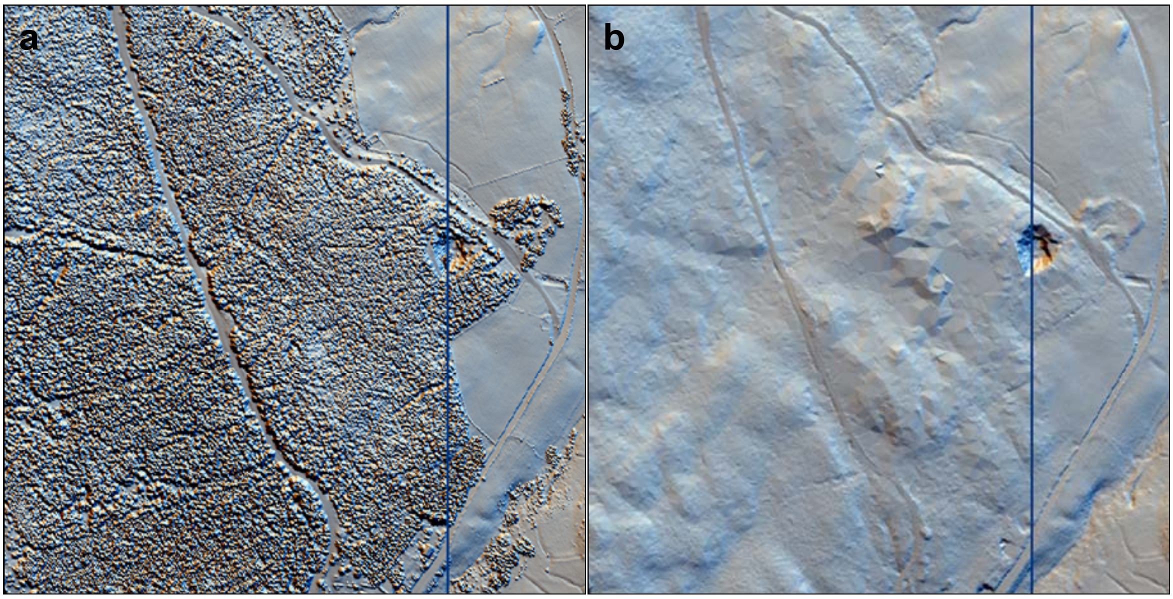


Figure 5.18
Beddgelert forest, south of Llyn Cwellyn, shown at 1:7,500

Multi-hillshade lidar digital *surface* model, showing dense forest (a) and multi-hillshade lidar digital *terrain* model (b) showing prism effect and smoothing where processing failed because of insufficient data returns.

See Appendix K, transcription map 11 for context
Centred on grid reference: 25690 35330

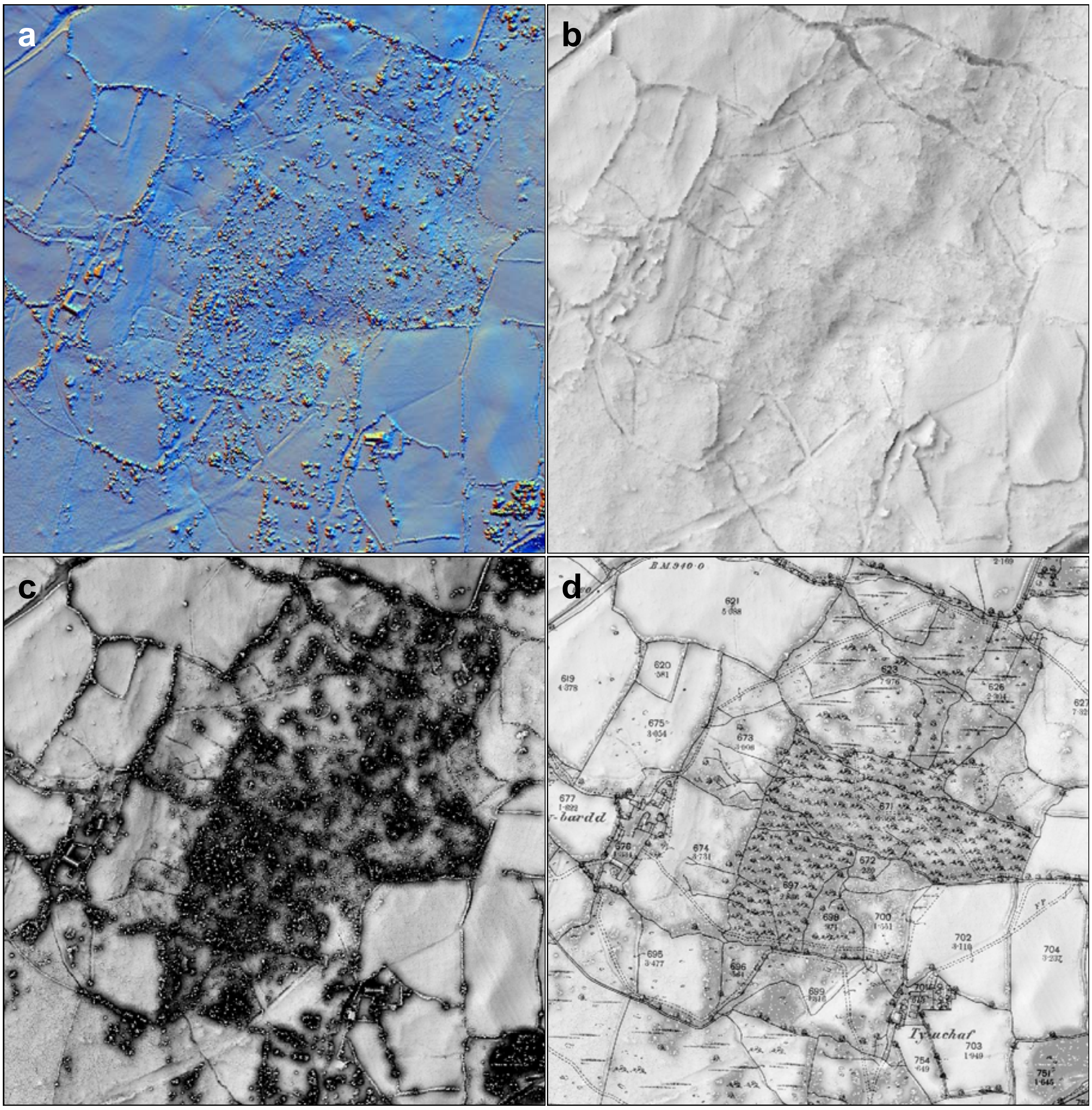


Figure 5.19
Woodland south of Rowen, on the lower slopes below Tal y Fan, shown at 1:7,500

Multi-hillshade lidar digital *surface* model, showing woodland (a), sky-view factor lidar digital *terrain* model (b), sky-view factor lidar digital *surface* model (c) overlain by 1st edition Ordnance Survey map (1885-87) (d). Comparison between these different models demonstrates the low data returns in areas of woodland and sky-view factor lidar digital *surface* model which shows field boundaries more clearly (c).

See Appendix K, transcription map 3 for context
Centred on grid reference: 27460 37170

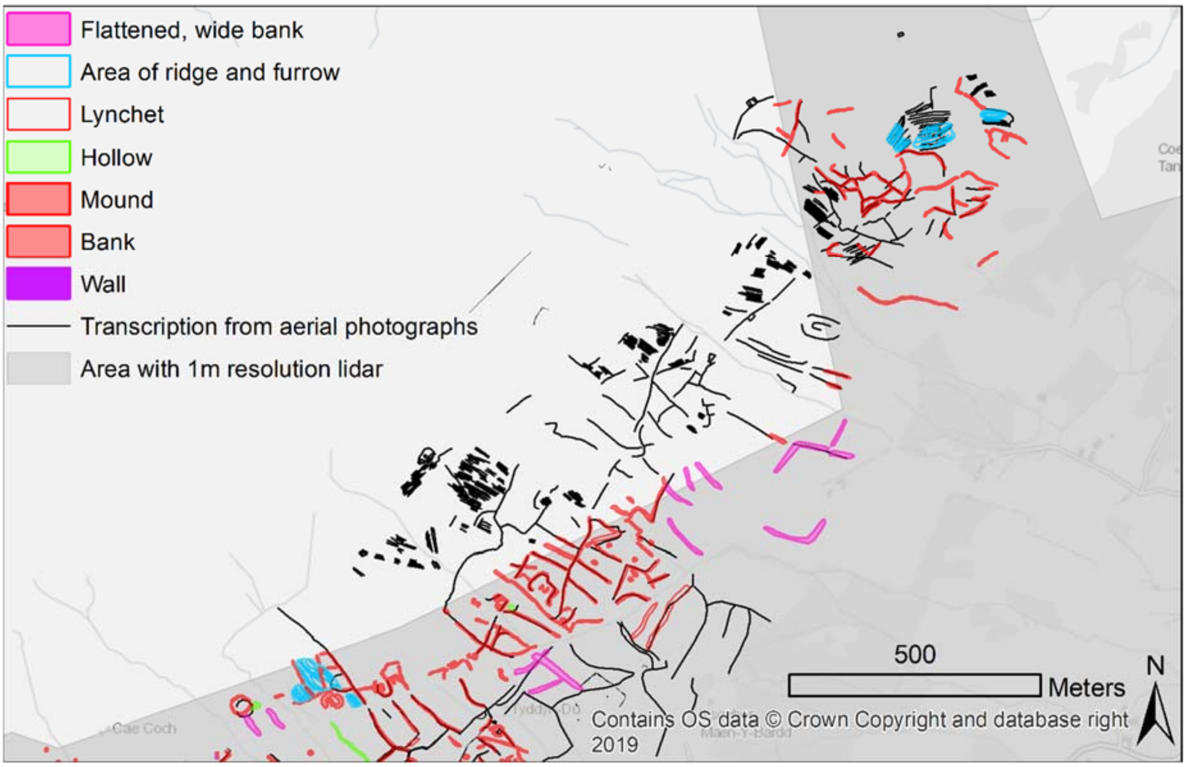


Figure 5.20
Maen y Bardd settlement and field system on the slopes below Tal y Fan, shown at 1:15,000

Features can be seen to continue beyond the area with lidar coverage. Comparison in areas with lidar coverage shows many features visible on the lidar which could not be observed on aerial photographs.

See Appendix K, transcription map 3 for context
Centred on grid reference: 27410 37190

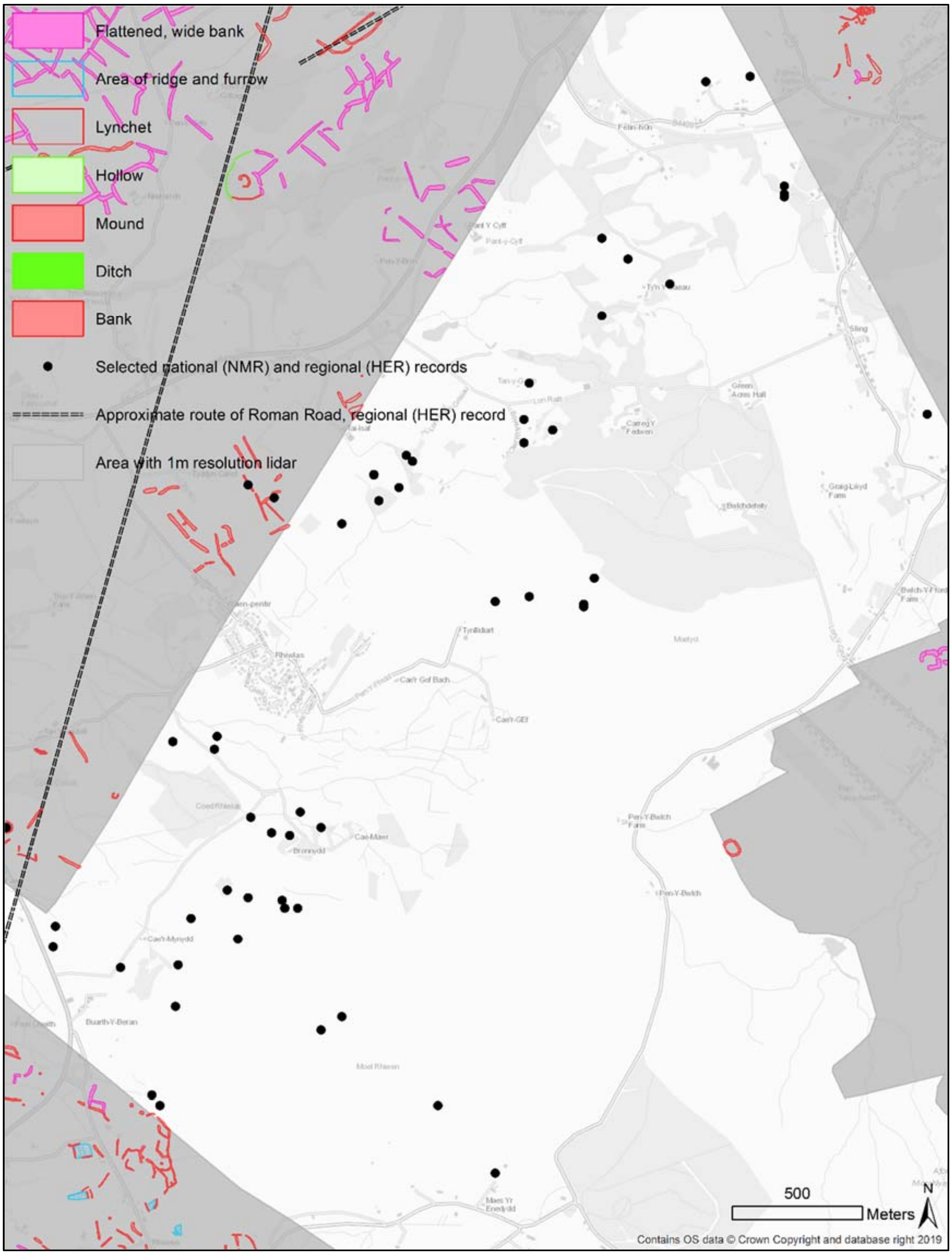


Figure 5.21
Lower slopes on the west and north sides of Moel y Ci and Moel Rhiwen, shown at 1:15,000

Selected records from the regional Historic Environment Record (HER) and National Monument Record (NMR) relate to fieldscapes, including 'field system', 'hut circle', 'cairn', 'house platform' and 'long hut'. The density of records indicates high potential for future lidar survey.

See Appendix K, transcription map 6 for context
Centred on grid reference: 25850 36540

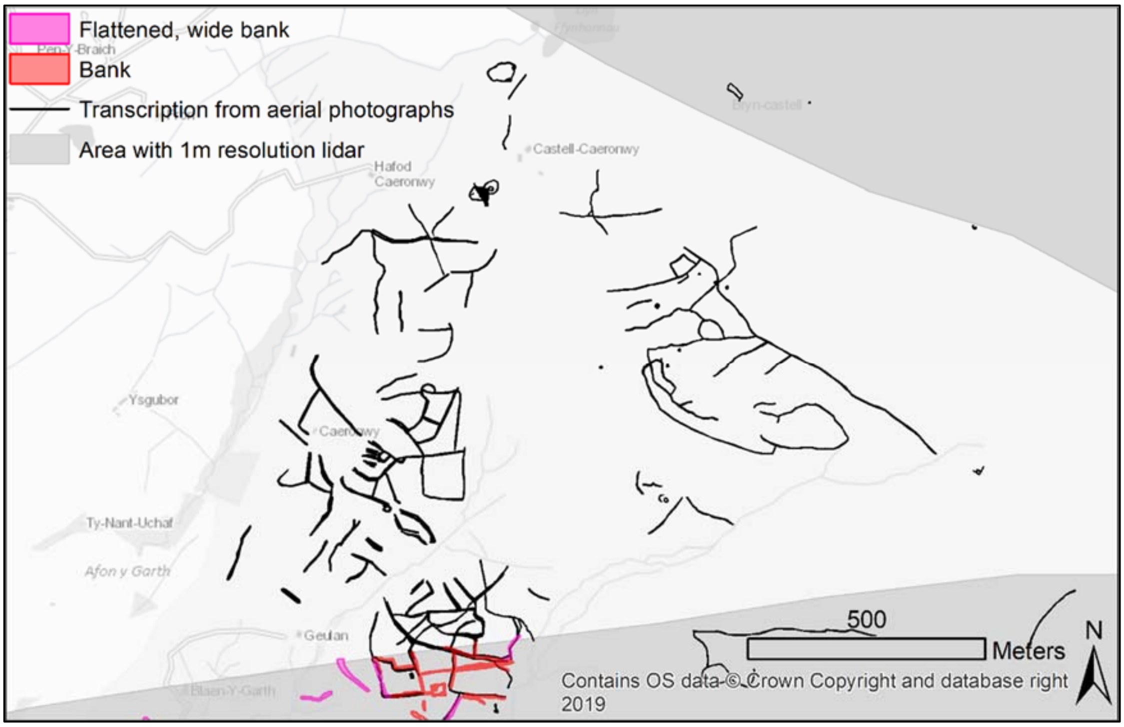


Figure 5.22
Area north of Nantlle, shown at 1:15,000

See Appendix K, transcription map 10 for context
Centred on grid reference 25205 35420

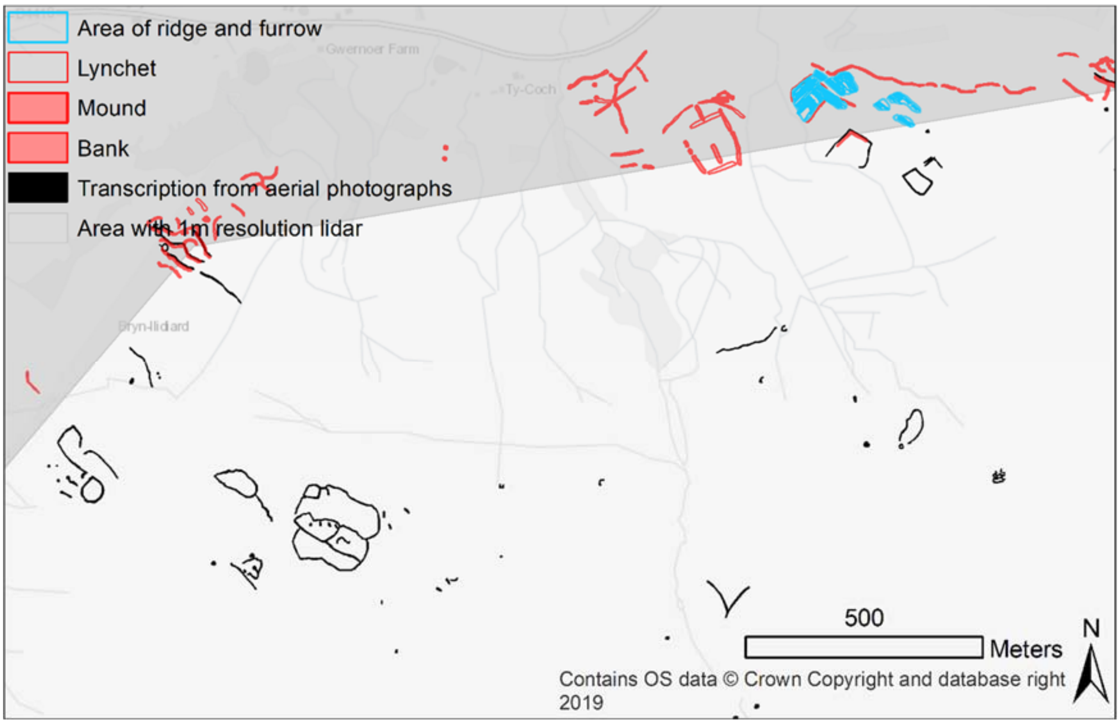


Figure 5.23
Area south of Nantlle, shown at 1:15,000

See Appendix K, transcription map 10 for context
Centred on grid reference 25010 35160

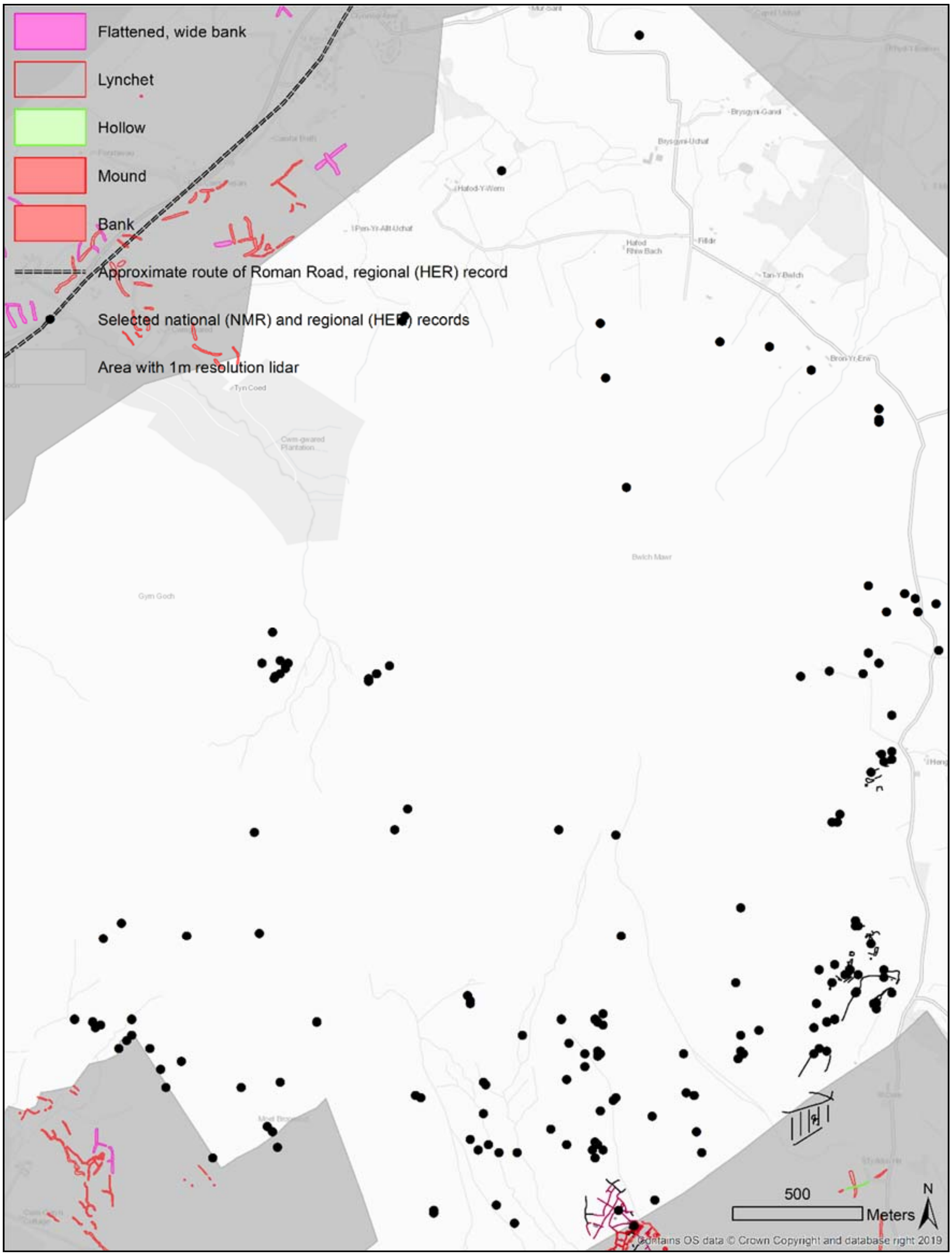


Figure 5.24
North and west facing slopes of Blwch Mawr, east of Clynnog Fawr, shown at 1:15,000

Early fields and areas of ridge and furrow cultivation recognised on the Records from the regional Historic Environment Record (HER) and National Monument Record (NMR) that relate to fieldscapes, including 'terraced ground', 'lynchet', 'clearance cairn', 'hut circle', 'cairn', 'house platform' and 'long hut'.
Centred on grid reference: 24230 34707
See Appendix K, transcription map 13

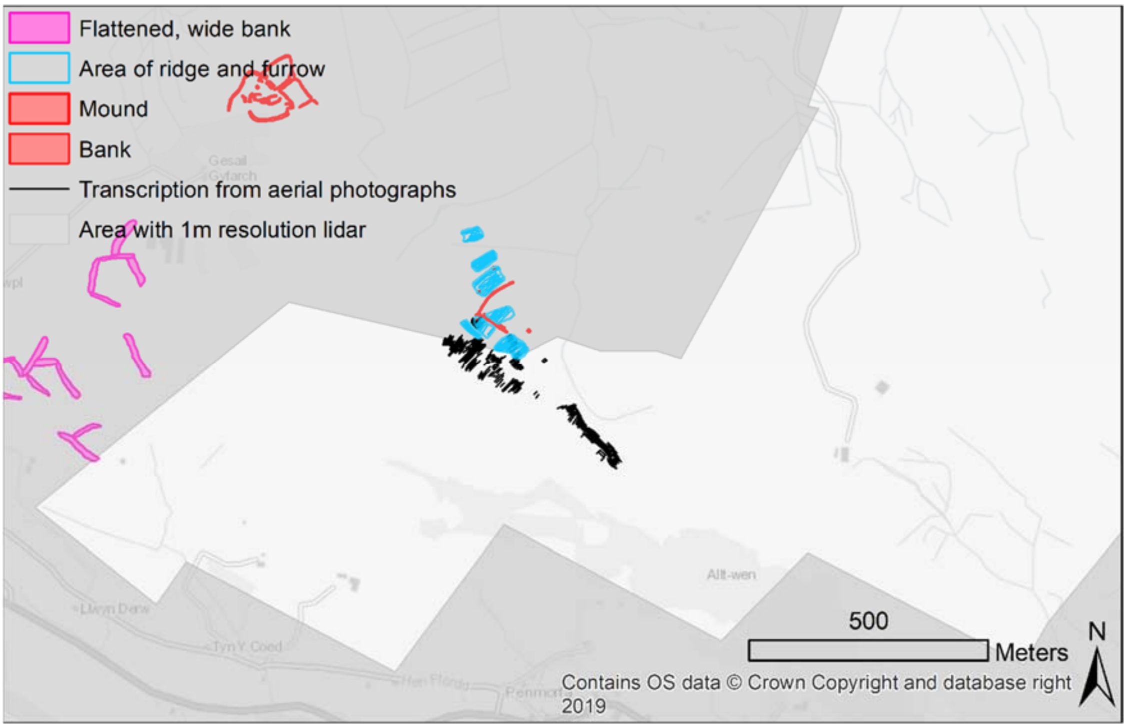


Figure 5.25
Area of ridge and furrow above Penmorfa, shown at 1:15,000

See Appendix K, transcription map 14 for context
Centred on grid reference: 25470 34130

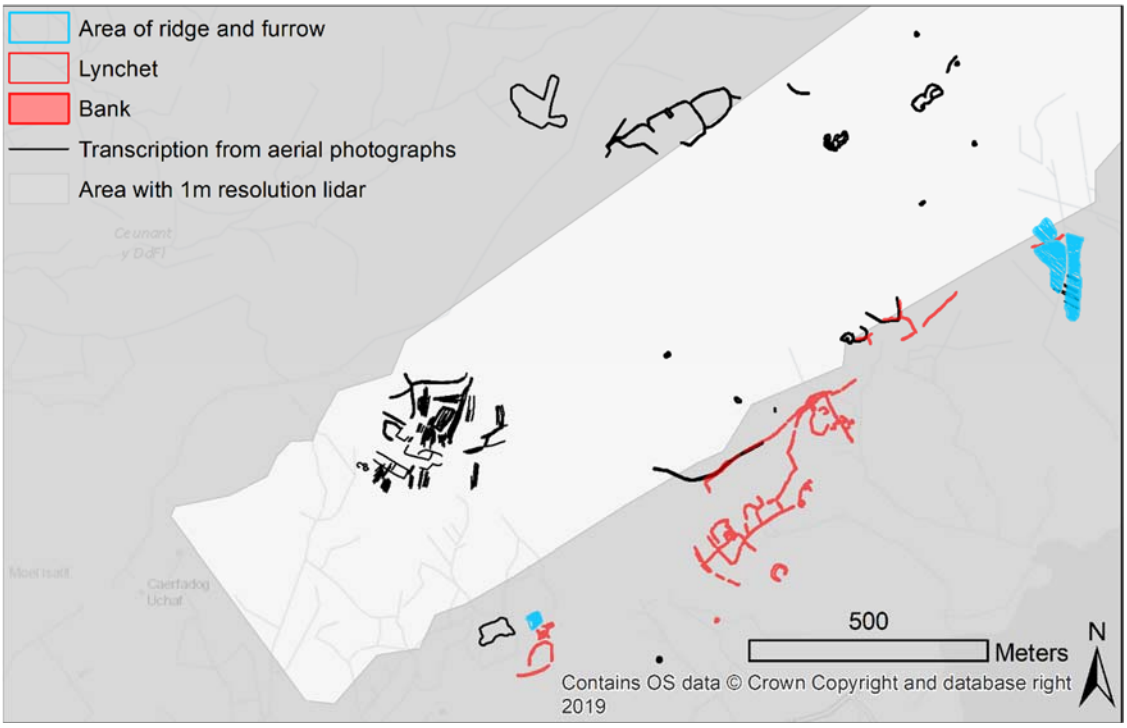


Figure 5.26
Settlement and early fields above Llanfihangel-y-pennant, Dolbenmaen, shown at 1:15,000

See Appendix K, transcription map 14 for context
Centred on grid reference: 25460 34480

Figure 5.27
Moel Goedog (west), above Harlech, shown at 1:15,000

See Appendix K, transcription map 17
Centred on grid reference 25860 33020

Figure 5.28
Moel Goedog (east), above Harlech, shown at 1:15,000

See Appendix K, transcription map 17
Centred on grid reference 26300 33425

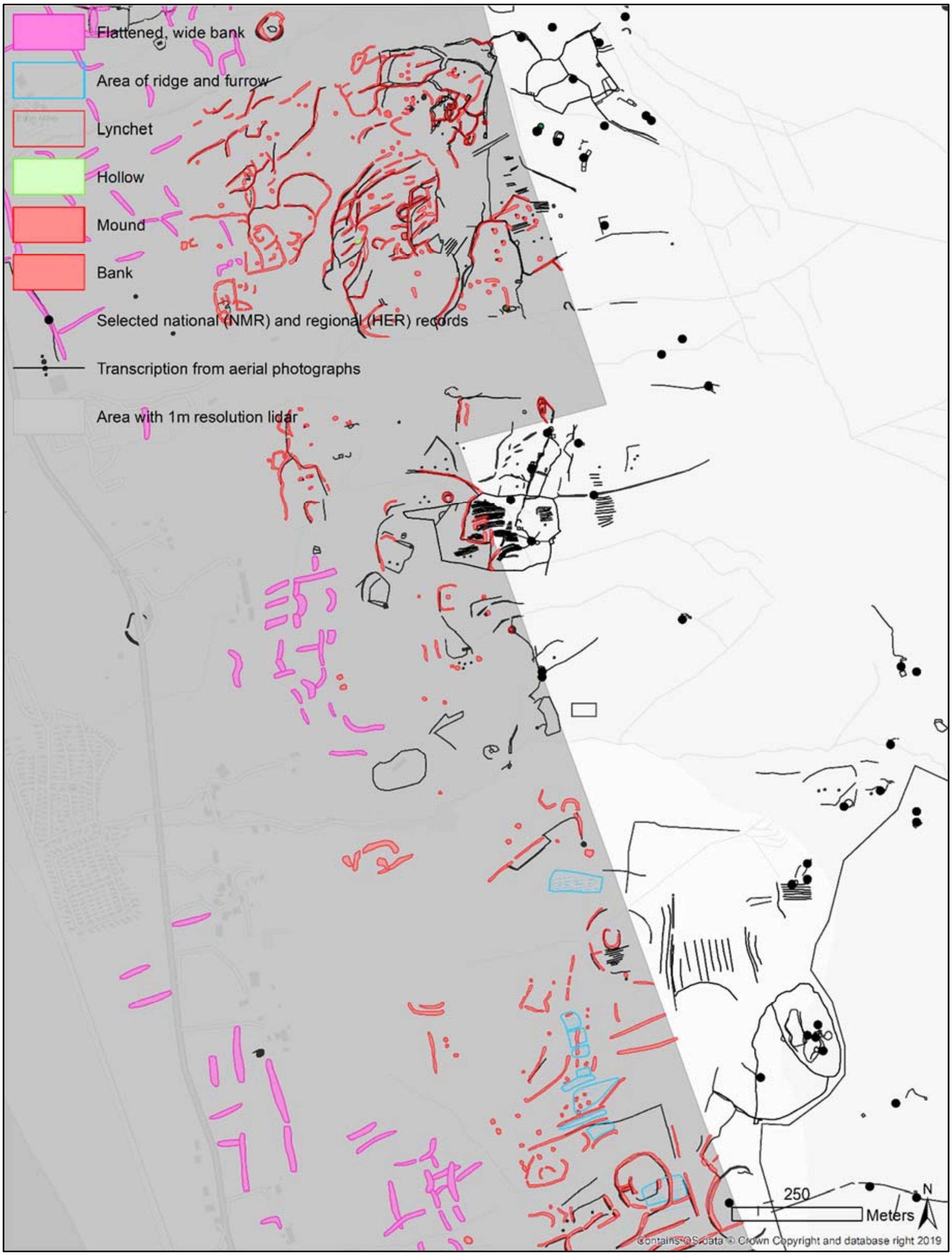


Figure 5.29
An extensive area on the uplands above Llanaber, shown at 1:7,500

See Appendix K, transcription map 19
Centred on grid reference: 26050 32000

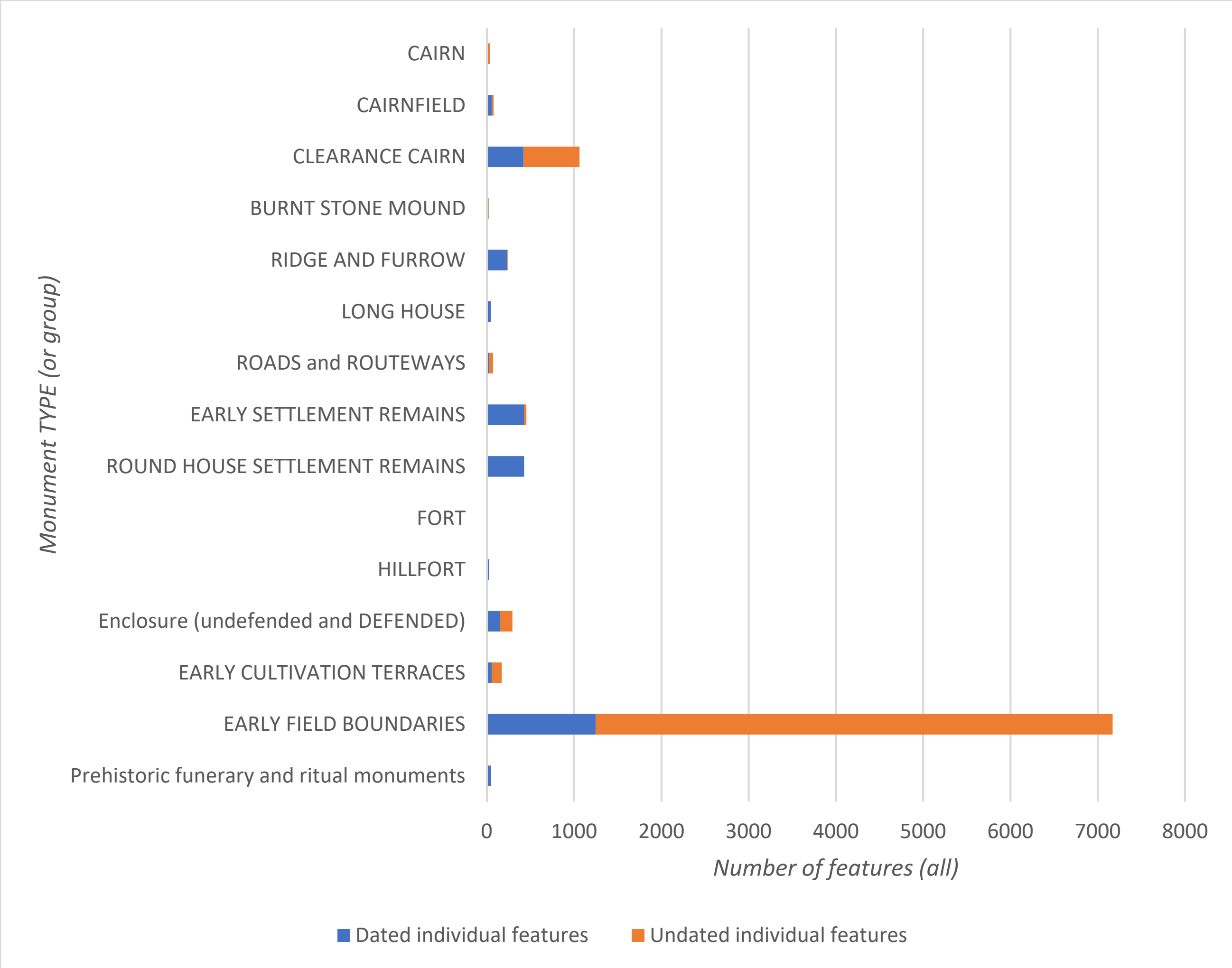


Figure 5.30
Distribution of dated and undated individual features

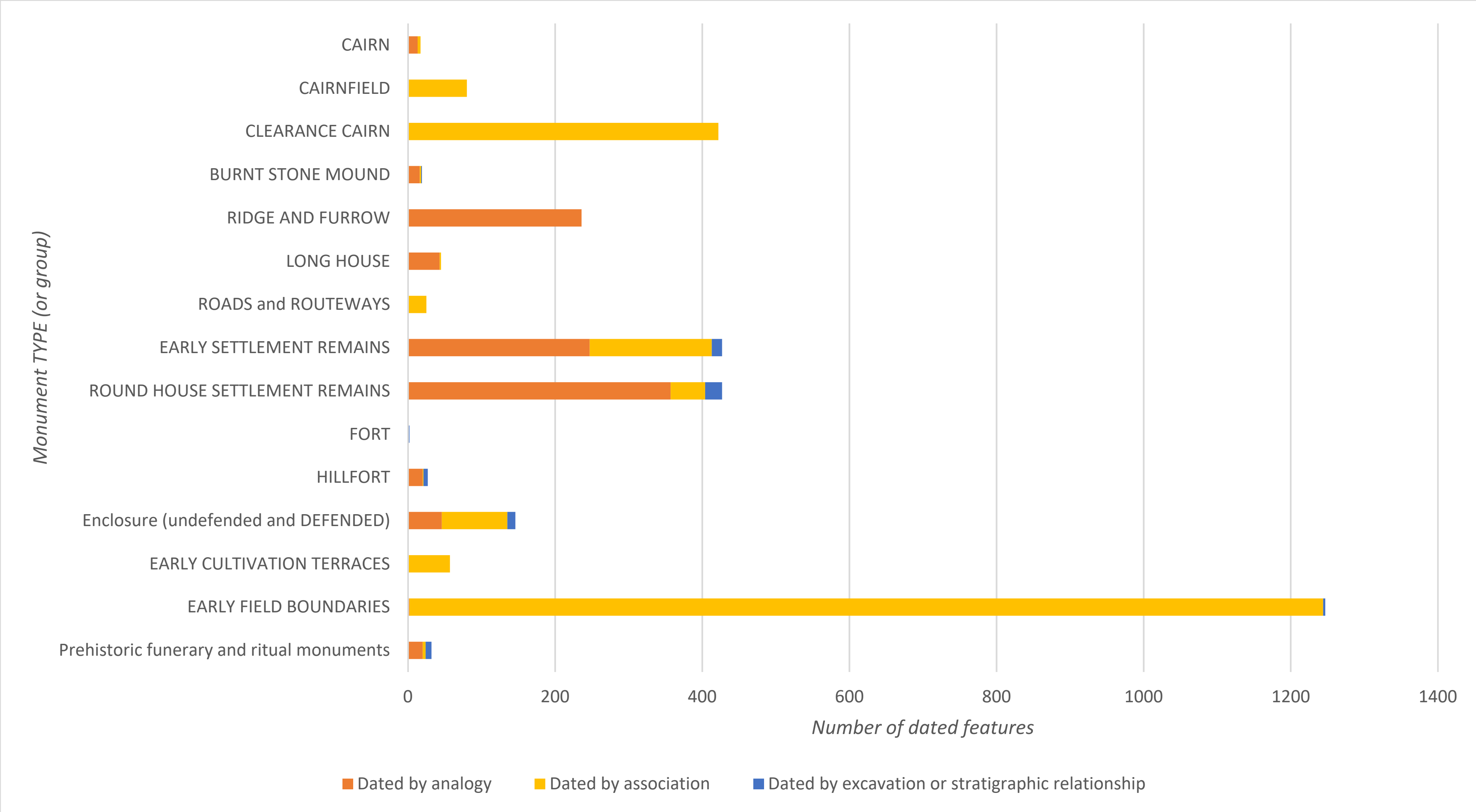


Figure 5.31
Distribution of dating type for dated features

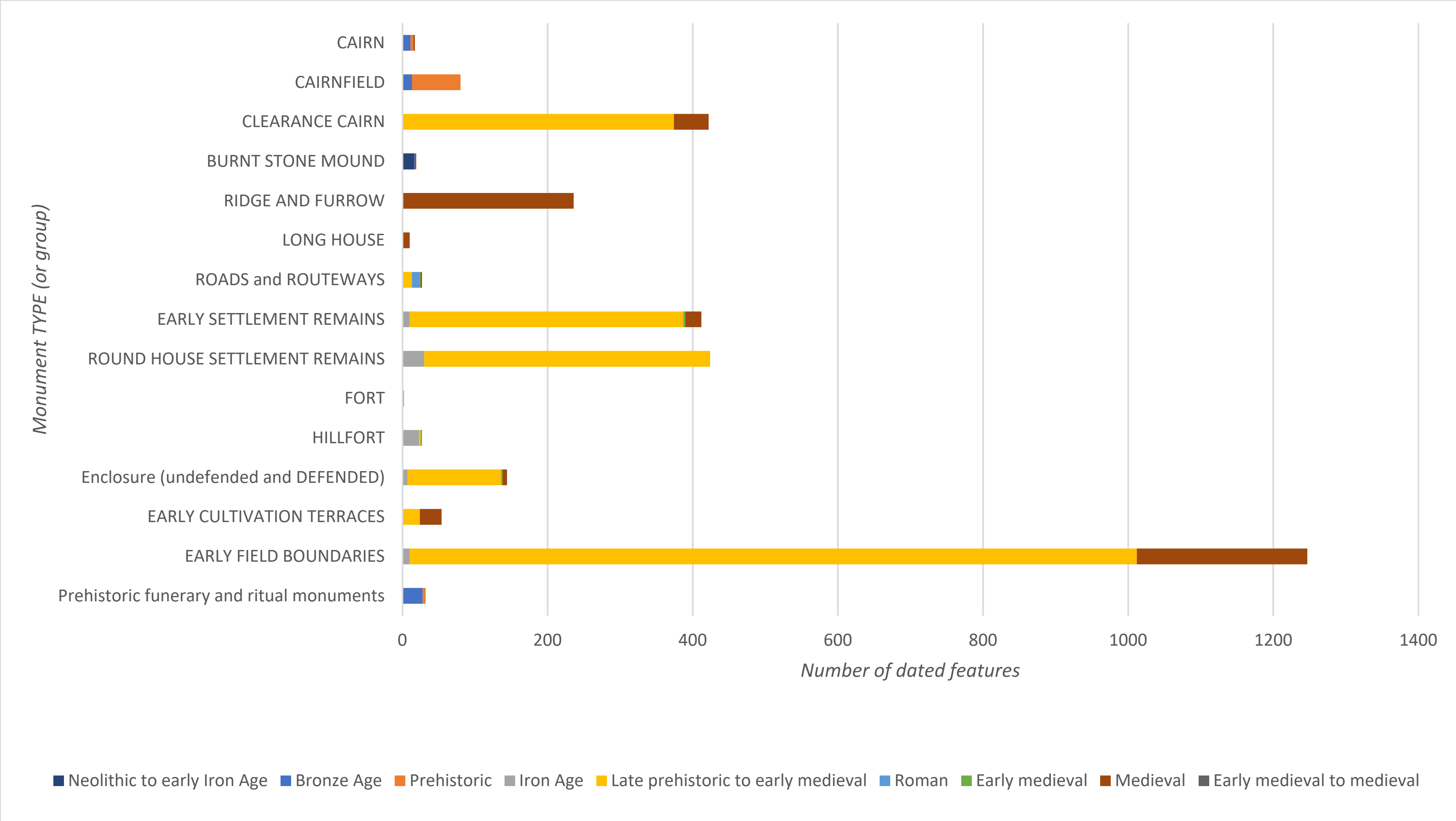


Figure 5.32

Distribution of period attribution for dated features

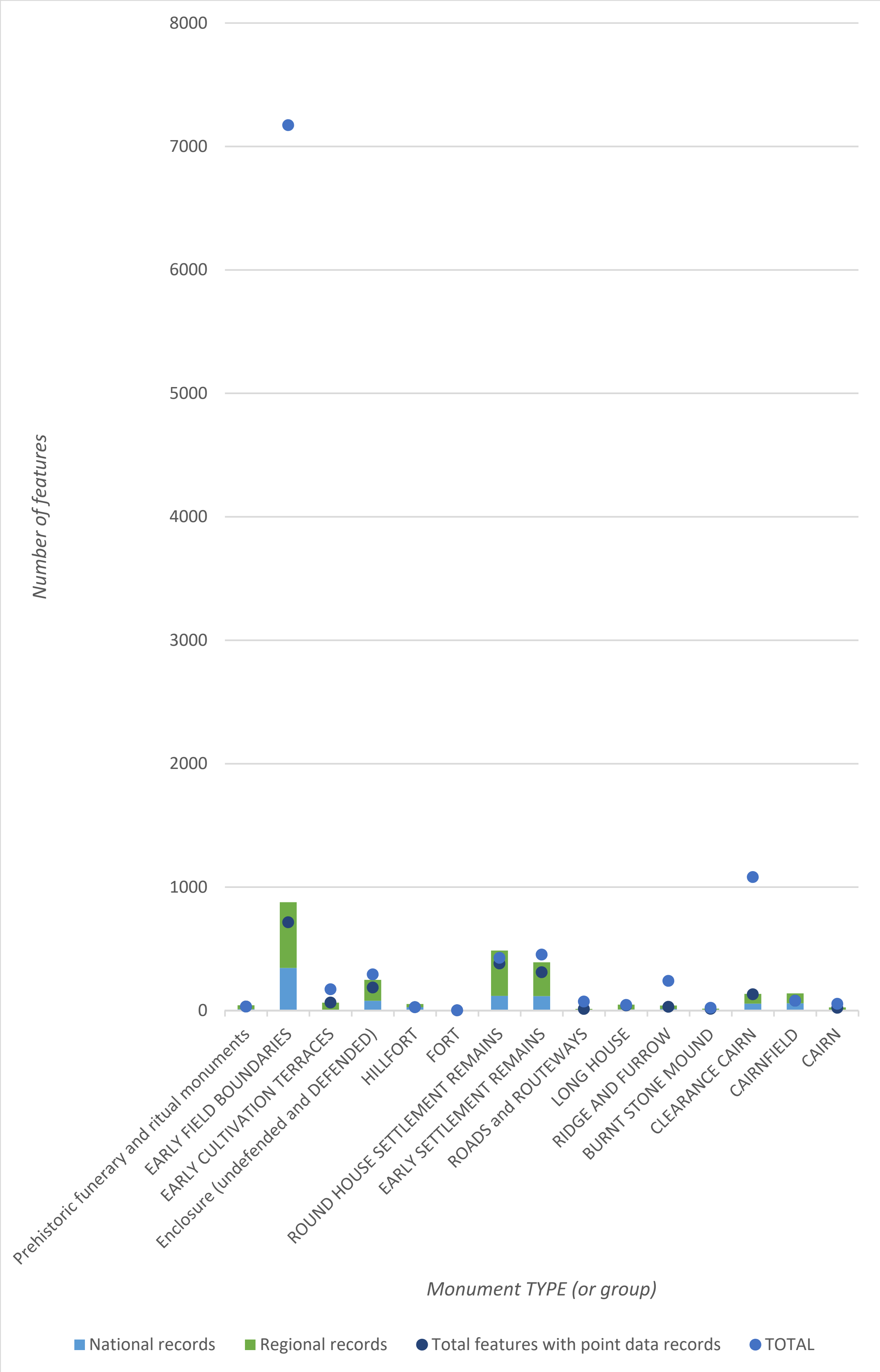


Figure 5.33

Numbers of features with national and/or regional records compared to early fieldscapes total

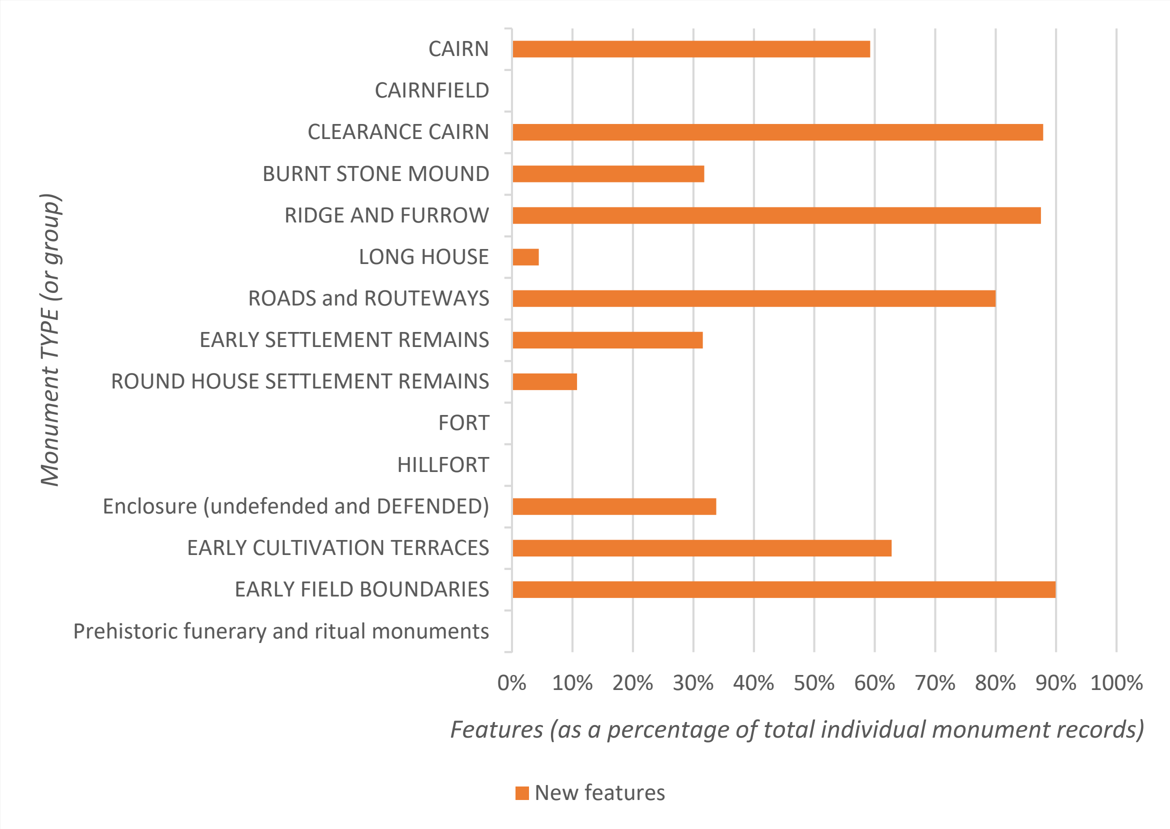


Figure 5.34
Newly recognised features

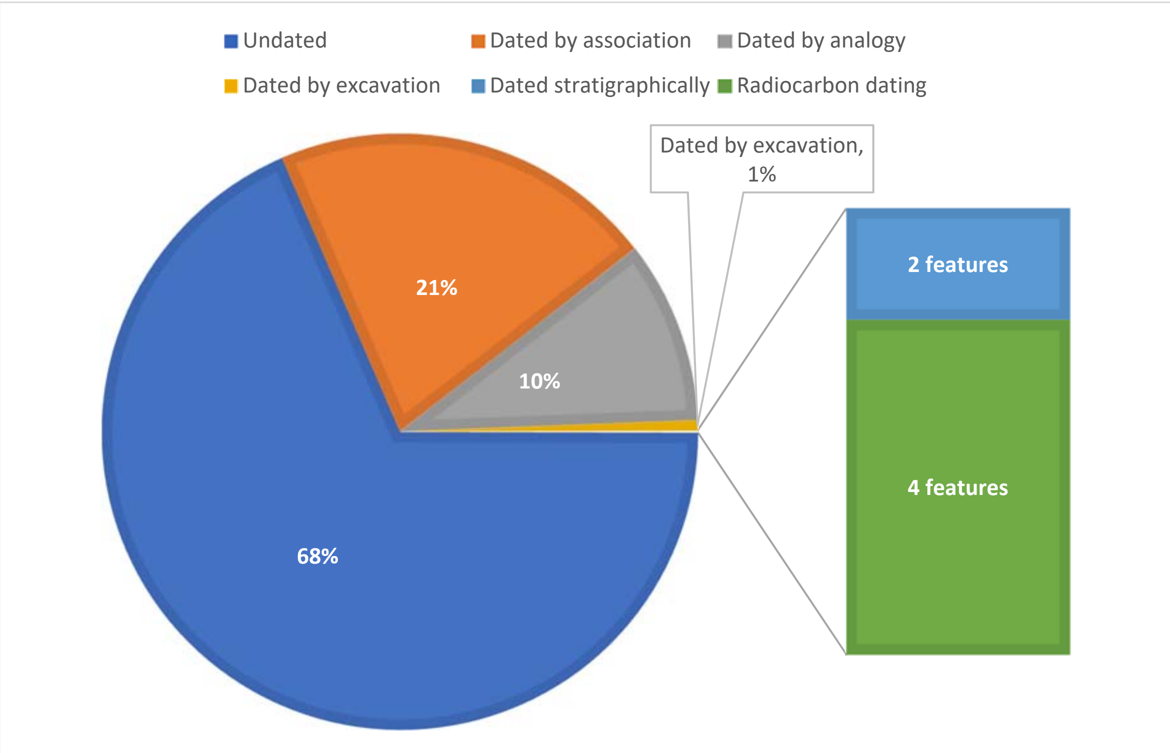


Figure 5.35
Dating type for categorised features (N=10253)

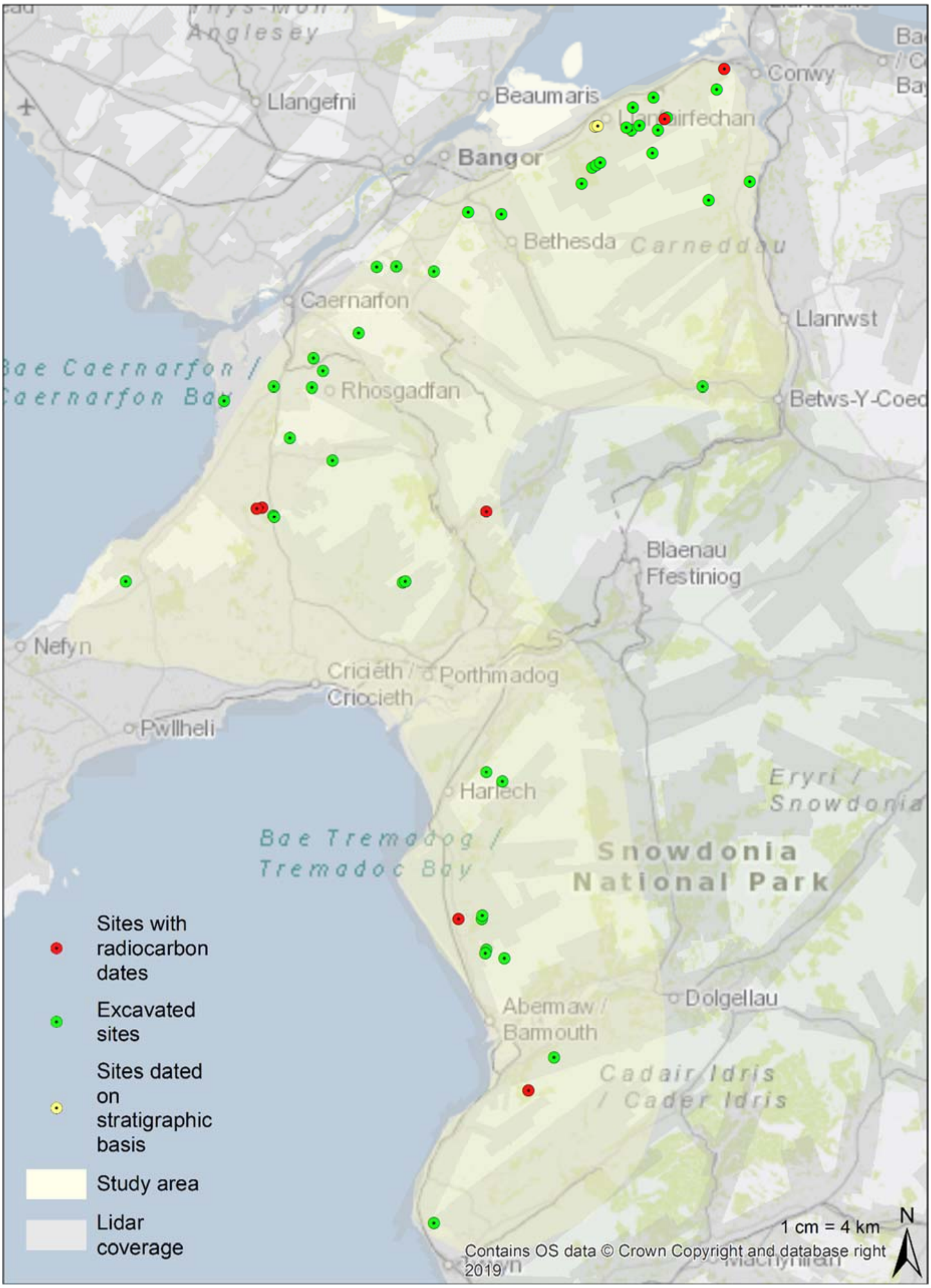


Figure 5.36
Excavated sites with and without radiocarbon dates, and features dated on the basis of their stratigraphic relationship to other sites

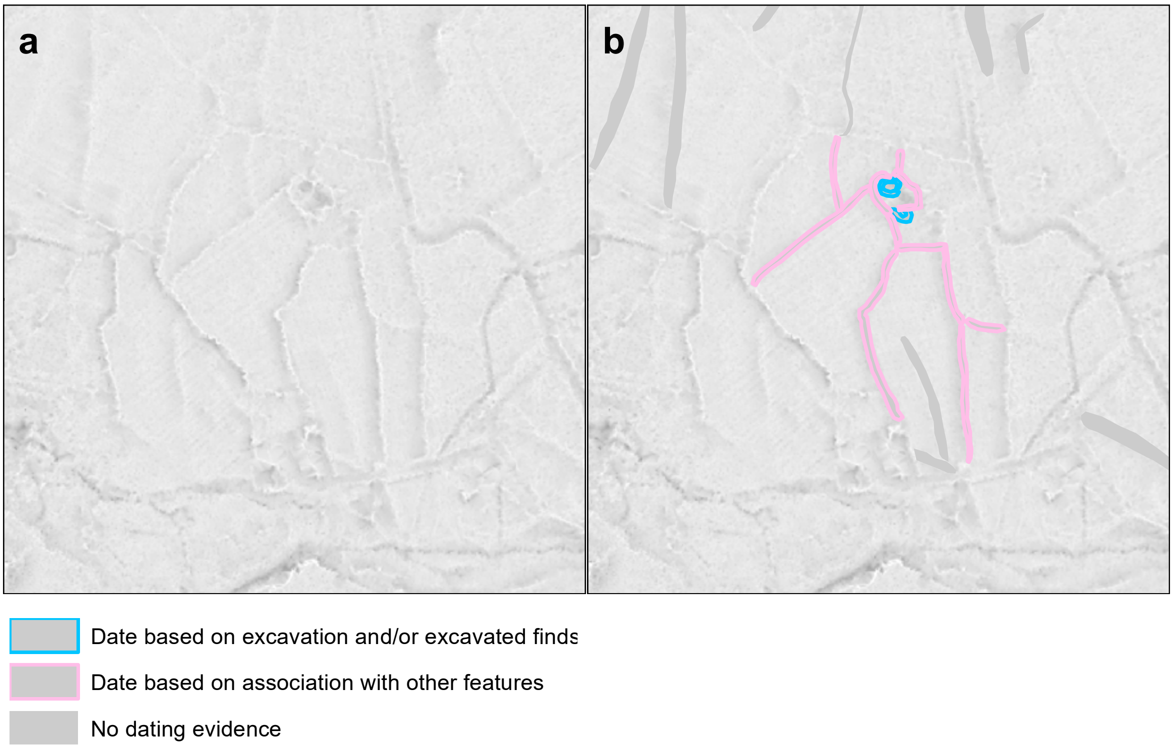


Figure 5.37
Coed Uchaf, Llanllechid, shown at 1:5,000

Open-positive lidar model (a) overlain by research categorisation dating type (b) shows enclosed round house settlement and associated terraced fields.

See Appendix K, transcription map 1
Centred on grid reference: 26160 36843

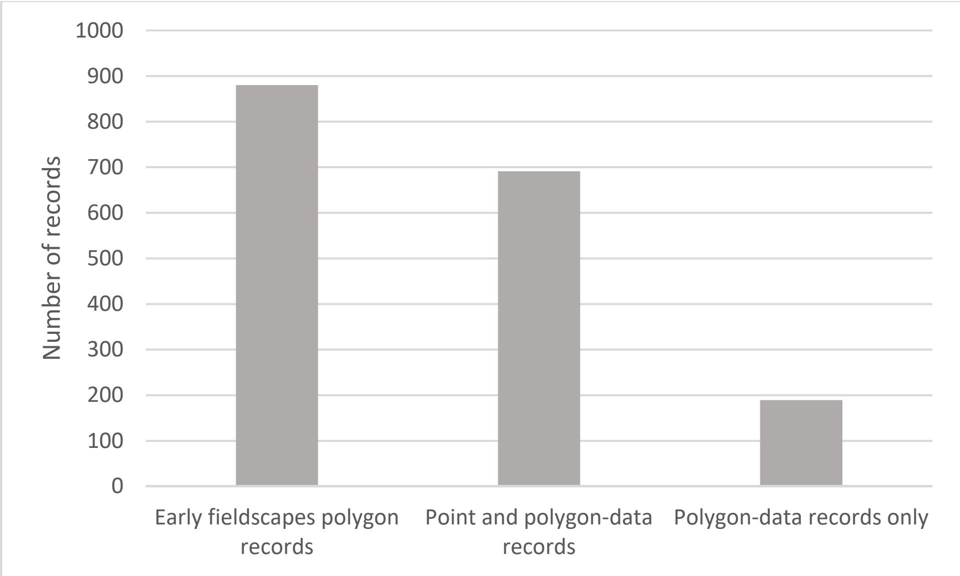


Figure 5.38
Bar chart comparing roundhouse records by record type

Total early fieldscapes polygon records compared with total early fieldscapes records with HER information (point and polygon) and those without (polygon only)

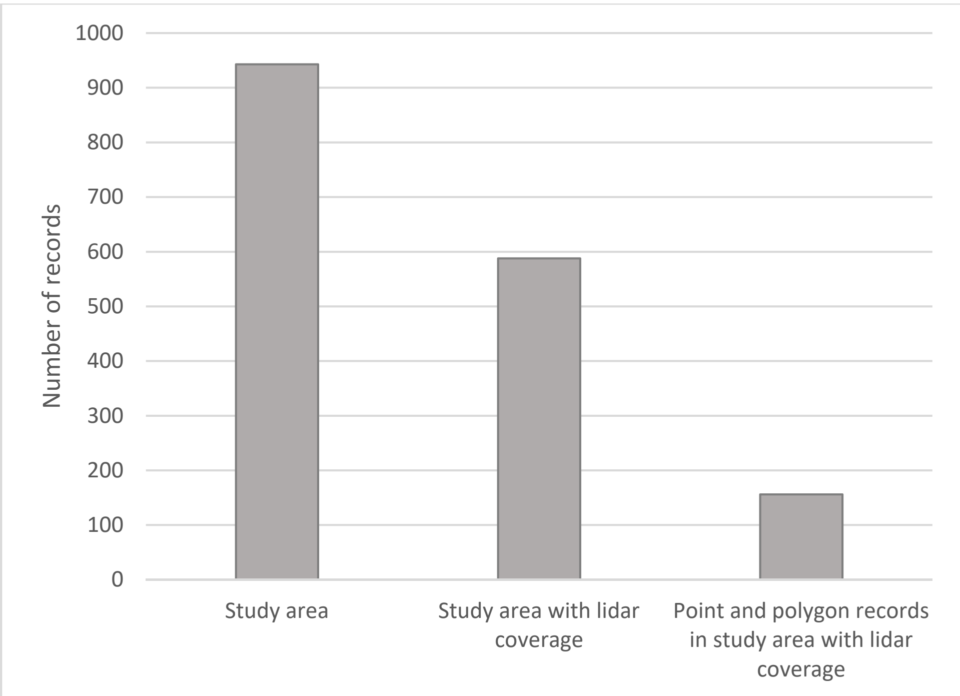


Figure 5.39
Bar chart comparing HER roundhouse records with early fieldscape study areas

'Study area' corresponds to total point records in the study area; 'study area with lidar coverage' is a subset of this total showing area with lidar coverage (and therefore potential for feature transcription); 'point and polygon records', is a subset of HER records which correspond with roundhouses identified on lidar models and transcribed as part of the early fieldscapes dataset.

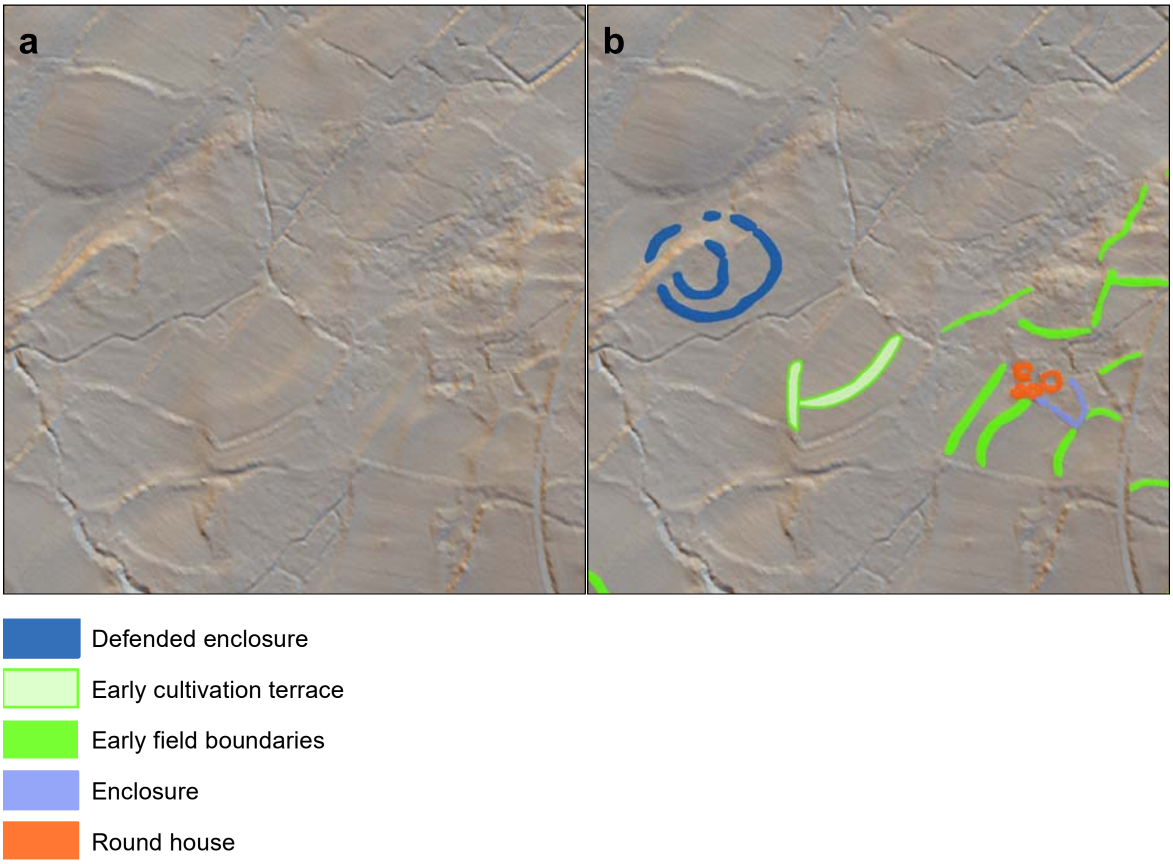
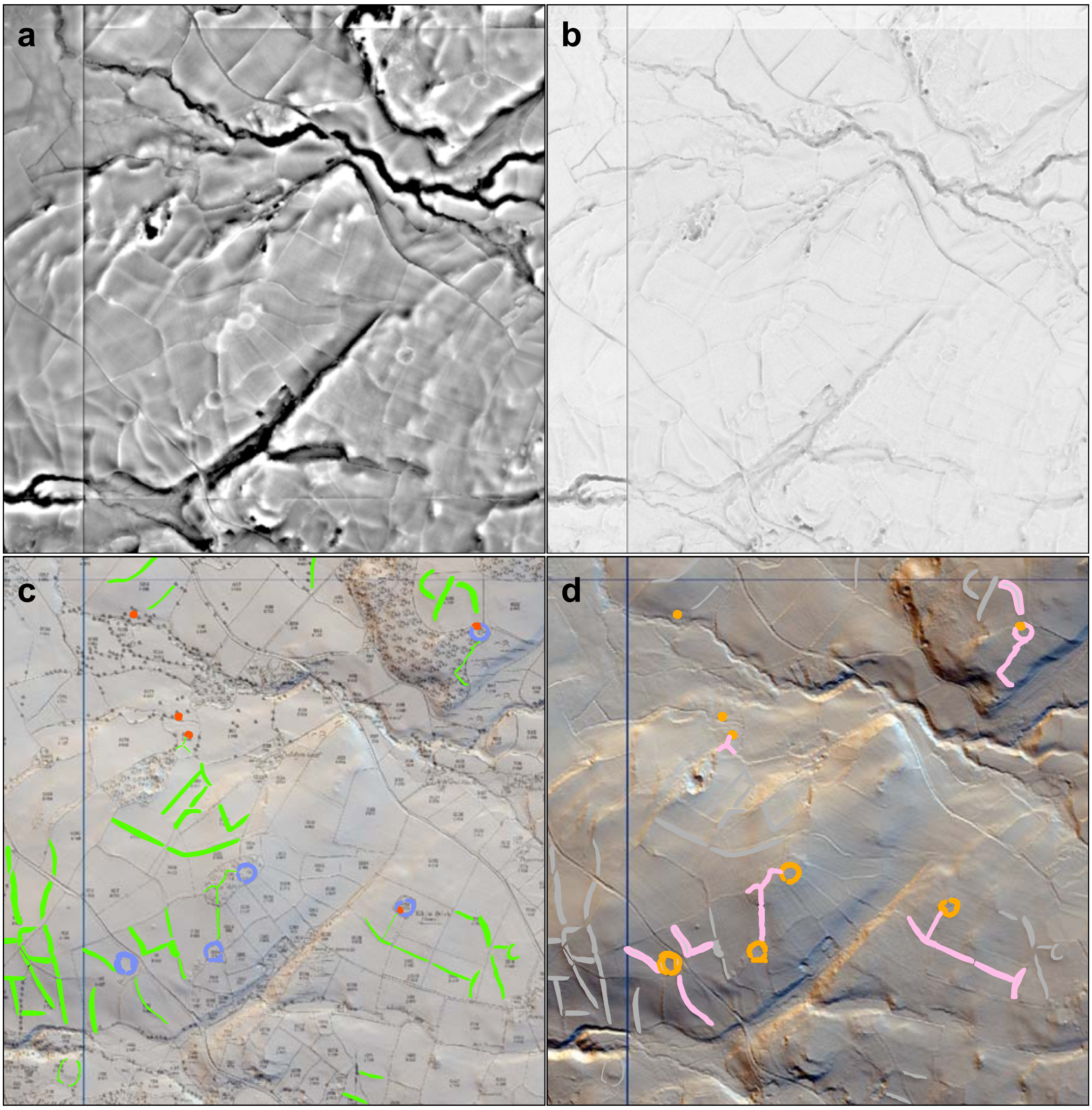


Figure 5.40
Rhos Isaf (probable) defended enclosure, Rhostryfan, shown at 1:5,000

Multi-hillshade lidar model (a) overlaid with research categorisation monument features (b).

See Appendix K, transcription map 5
Centred on grid reference: 24916 35729



Early field boundaries

Enclosure

Round house

Date based on analogy

Date based on association with other features

No dating evidence

Figure 5.41
Enclosures and roundhouse settlements, north of Llanllechid, shown at 1:15,000

Comparison between monument research categorisation (c) and dating type (d) overlain on lidar models. Simple local relief model (a), open-positive models (b), 1st edition survey map (1885-87) overlain on multi-hillshade model (d).

See overleaf for more details

See Appendix K, transcription map 1
Centred on grid reference: 26150 36940

Contains Natural Resources Wales information © Natural Resources Wales and database right
1:2500 County Series 1st edition [TIFF geospatial data], Scale 1:2500, Tiles: caer-sh6170, caer6169. Updated 30 November 2010, Historic, Using EDINA Historic Digimap Service, <http://digimap.edina.ac.uk>, Downloaded: 2018-02-02 15:25:56.039

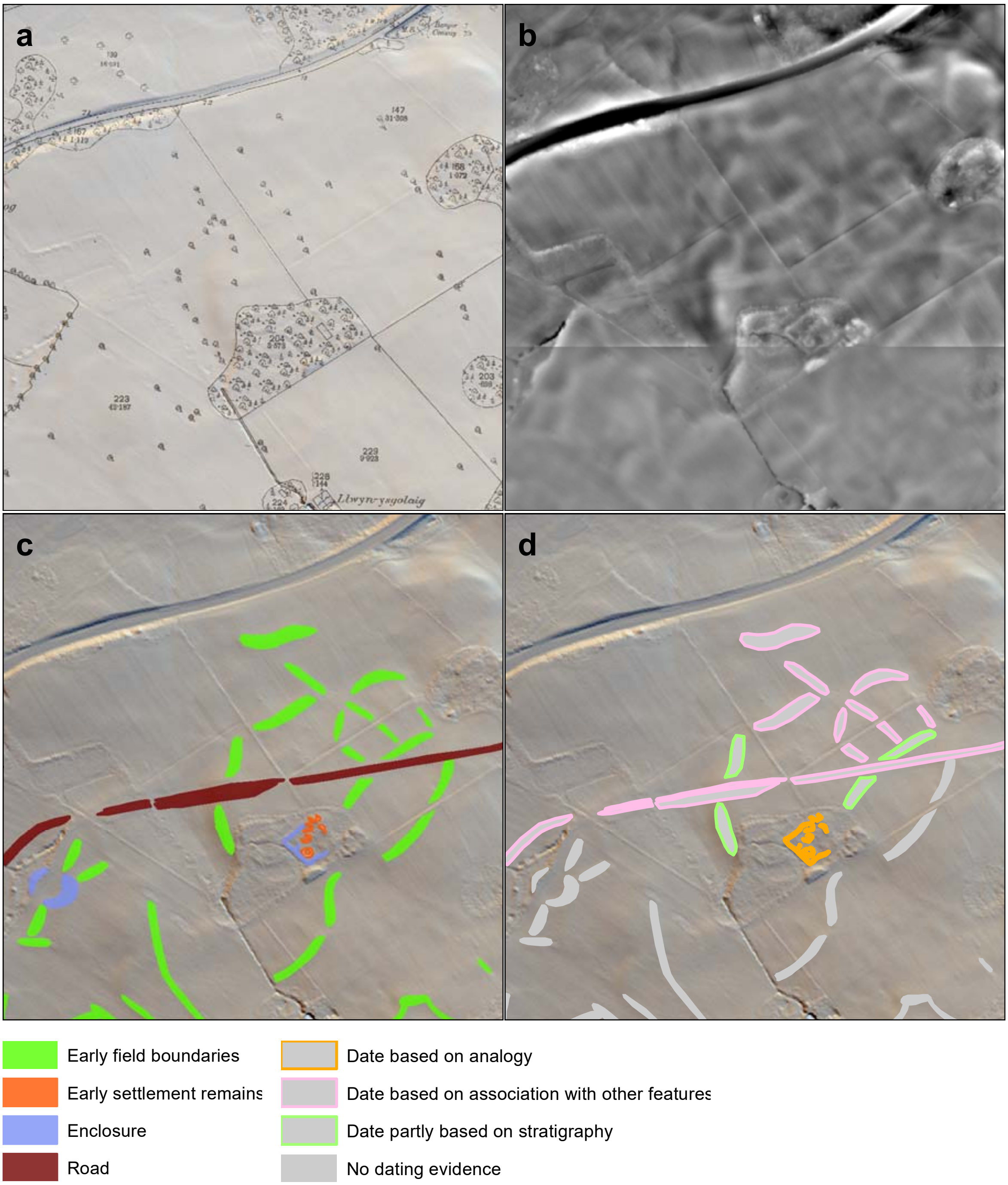


Figure 5.42
Field boundaries underlying possible Roman road, west of Llanfairfechan, shown at 1:7,500

Comparison between monument research categorisation (c) and dating type (d) overlain on multi-hillshade lidar models; 1st edition survey map (1885-87) overlain on multi-hillshade model (a), simple local relief model (b).

See Appendix K, transcription map 2 for context
Centred on grid reference: 26774 37408

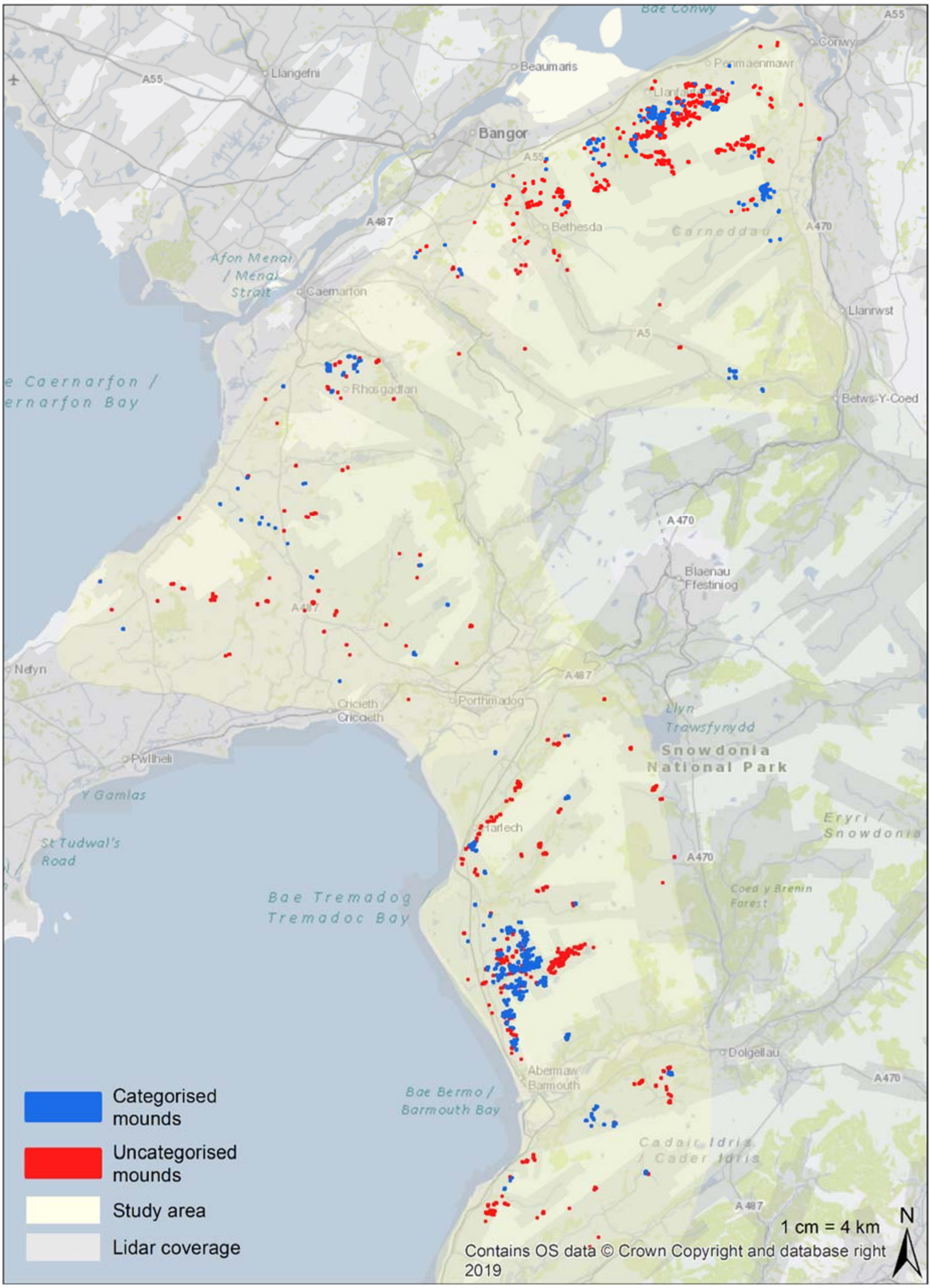


Figure 5.43
Categorised and uncategorised 'mounds', shown at 1:350,000

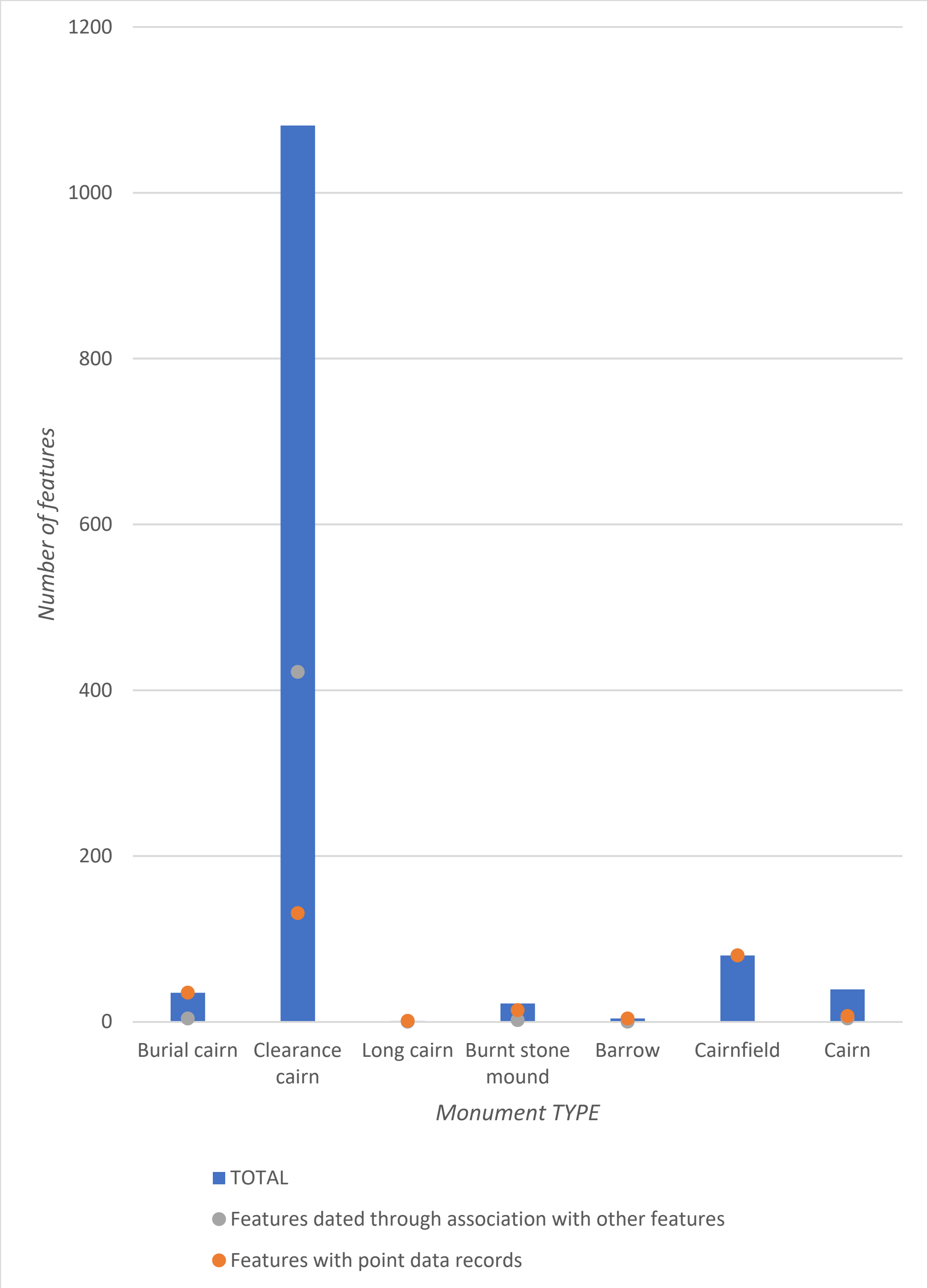


Figure 5.44
Mound features categorised by archaeological monument type

Chapter 6
Macro-Scale Results: analytical statistics

Developing geostatistical approaches to early fieldscapes

The large sample size, rich metadata and consistency of the early fieldscapes dataset created new opportunities for geostatistical analysis. Developing the best approach involved first identifying and selecting variables that were relevant to the principal aim of the thesis and research questions. These highlighted the importance of understanding geographic distribution, preservation (question 1), form, cohesion and temporality (question 2) of early fieldscape features, all of which were central to the development of new methods (question 3).

1. What human and environmental processes explain the geographical distribution and preservation of early fieldscapes?
2. What does the form and cohesion of fieldscapes reveal about the organisation and temporality of enclosure?
3. How can spatial data structures and geostatistical methods be refined in support of analysing and understanding early fieldscapes?

A matrix of variables was collated to guide this process: Table 6.1 details the feature attribute variables, Table 6.2 includes information from additional sources, referred to as context variables. In addition to the x-y spatial attributes, three new datasets were generated from the transcription and research categorisation datasets, using existing tools available in ArcGIS to capture associated characteristics with high analytical potential:-

1. Absolute feature elevation using 1m resolution lidar digital terrain models (minimum, maximum, range, mean and standard deviation).[74]
2. Feature slope using 1m resolution lidar digital terrain models (minimum, maximum, range, mean and standard deviation).[75]
3. Line length for linear polygons, specifically banks, ditches and lynchets, using a methodology outlined below (Table 6.3).

The context variables took time to select. The growth in new datasets, data, and availability across a wide range of disciplines, supplied by different organisations and creators, offers great potential but also some challenges. Datasets usually require specific knowledge and skills to use properly, they

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[74] Feature elevation data was generated using the Add Surface Information tool in ArcGIS ArcToolbox
[75] Slope data was generated using the Add Surface Information tool in ArcGIS ArcToolbox.

may be offered at different levels of resolution and can require large processing capacity (for example lidar models). Variables used in previous studies (e.g. Wickstead 2008b, English 2013, Brown 2016, Gosden et al. In Press-a), primarily for correlation analysis, are elevation, slope, aspect, insolation, precipitation and land-use, and these have been included here as options. Datasets used during the digitisation process, such as the 1m resolution lidar models and monument record data, have also been evaluated.

Matrix results

The feature attribute variables and context variables were ranked as having high, medium or low potential to help inform the research questions. They had the highest potential for determining preservation and geographic distribution, slightly lower potential for analysing form and cohesion, and low potential value for the analysis of temporality. Many variables were categorical (that is discrete and qualitative) and less well-suited to geostatistical analysis.

In the light of this, the analysis focused on the continuous interval and ratio variables for the fieldscape datasets and on using these to understand where fieldscapes are best preserved and most coherent, that is, where they have the greatest *integrity*. These results guided more detailed analysis of form, that is, their *character*. Areas with the greatest integrity were better suited for further analysis exploring the relationship between different fieldscape elements.

Applying geostatistical approaches to assess the integrity of early fieldscapes

The survival (preservation) and coherence of early fieldscape features was assessed using two principal geospatial techniques, developed in collaboration with Stephen Hincks[76]:

1. A method for assessing the relative height of features;
2. A grouping analysis method to assess clustering and proximity of early fieldscape monument types.

(1) Relative Feature Height (RFH)

The height of a feature relative to the surrounding ground surface was identified as a potential measure for feature survival, given the vulnerability of earthworks to erosion through agricultural activities. Preliminary analysis showed that boundaries on lower-lying land were affected most severely, where they survive as flattened, wide banks (as outlined in chapter 5).

A method for assessing Relative Feature Height (RFH) was developed using the composite 1m lidar data to create a DEM for measuring height values within and adjacent to features, as outlined in

[76] Urban Studies and Planning, University of Sheffield

Table 6.4. Details for the new attribute fields are included in Appendix L (Tables L1 and L2). In summary, the RFH approach focused on measuring the difference in elevation between the minimum and maximum value in a moving 3m by 3m cell neighbourhood. Zonal statistics were calculated in ArcGIS for each digitised feature using the transcription as the input feature dataset. The results are grouped and visualised using categories and displayed using graduated symbology. The dependent variables and derivation of categories for assessing the mean RFH are outlined in Table 6.5. The mean RFH categories are based on the Natural Break (Jenks) classification method, and positive and negative categories use mean RFH above and below 0m, that is above and below sea level. The application of Natural Breaks (Jenks) classification by ArcGIS identified five groups of features, based on values that minimise variation within each range and maximise differences between them.

RFH results

It is important to note that although the method generates values (not indexes or ratios) they are summary approximations for features and are not a substitute for detailed field survey; feature size and variation, 1m DEM resolution and the use of 3m neighbourhood cell measure all affect accuracy. A strategy to target individual features for measured survey could (and should) be developed in the light of the RFH results, though this was beyond the scope of the current study. Preliminary ground truthing of the digital data confirmed that it is a useful measure.

Analysis of the transcription dataset using the positive and negative mean RFH categories demonstrated a strong association between mean RFH and feature type: hollows, pits and ditches had largely negative values whereas banks, mounds, walls and structures were mainly positive (*Figure 6.1*). Minimum, maximum, range and standard deviation were also calculated for RFH. The frequency distribution for standard deviation across the dataset had a low level of variation, indicating mean RFH values are a good proxy for the whole feature.

Analysis of the research categorisation dataset using the Natural Breaks (Jenks) classification method showed that more than 90% of monuments had a mean *mean* RFH of less than 8.07cm (*Figure 6.2*). However, the *maximum* RFH tells a different story, with 80% of monuments having a value greater than 8.07cm. As noted above, caution must be exercised treating these measurements as real-world values, however, they point to a couple of conclusions. Firstly, they confirm that working with lidar models has increased the identification of extensive features with more subtle surviving remains, reducing the mean RFH because the sample includes a larger number of very low-lying features and features that include low-lying extents; for example, there are longer stretches of boundaries with less prominent earthworks and a greater number of wide, flattened banks in coastal areas. Secondly, they show that while the mean RFH is a good proxy for comparative analysis between features, the range (minimum and maximum values) captures the variation within an individual feature. Features with a higher maximum RFH will be easier to identify on the ground and are more likely to have been recognised during previous field survey work.

This association can be observed by comparing the distribution of mean RFH (*Figure 6.3*), numbers with national or regional record information (*Figure 5.34*) and percentage of newly recognised sites (*Figure 5.35*) for monuments. The maximum *maximum* RFH for categorised features which are included in national or regional monuments is 2.19m, confirming better identification and recording for features with more prominent elements (Table 6.6). Analysis for features surviving within scheduled areas indicates a higher RFH for all measures (mean *mean*, maximum *mean*, mean *maximum* and maximum *maximum*) compared to features not protected by designation, indicating better preservation.

Statistical analysis of boundaries confirmed and refined the differences between boundary type, elevation and levels of survival observed in the descriptive analysis (chapter 5). Banks and lynchets had a higher mean RFH than flattened, wide banks commonly found on the coastal lowlands (*Figure 6.4*, Table 6.7). More generally, features located at lower elevations had a lower mean RFH and the converse was true for those at higher elevation. This pattern can be seen in areas with features that survive in upland and lowland settings, such as those at Llanfairfechan and Ardudwy, where the mean RFH is associated with feature elevation (*Figure 6.5*, *Figure 6.6*, *Figure 6.7*, *Figure 6.8*). These examples also illustrate the significance of feature proximity, explored in the next section through the second geospatial technique used to assess feature survival and coherence: Grouping Analysis.

(2) Grouping Analysis

The coherence of early fieldscape features was assessed using a method adapted from a Grouping Analysis geospatial approach originally employed elsewhere (Martin et al. 2020). The grouping analysis tool (ArcGIS 10.6) makes use of unsupervised learning methods[77] to identify natural groupings that maximise within-group similarity and between-group differences based on specified structural features and/or spatial constraints (*Figure 6.9*). The clustering exercise for early fieldscape features was based exclusively on *locational traits*, with x and y coordinates forming two variables that were used to determine the structure of the groups of features. The result was the creation of

[77] Unsupervised machine learning looks for previously undetected patterns in a data set with no pre-existing labels, classifications or categories, and with a minimum of human supervision. Cluster analysis is one of the most common unsupervised learning methods used to group datasets with shared attributes.

groups of features with similar locational profiles, but which do not necessarily share similar structural characteristics.

The use of simplified locational traits in Grouping Analysis required the conversion of the original polygonal dataset into point objects, in order for an x and y coordinate to be generated. While the creation of a centroid for each feature is straightforward, the reduction in locational detail introduced potentially significant distortions to the grouping analysis. For example, there was a risk of overrepresenting smaller, discrete features such as cairns and underrepresenting larger features. To mitigate this effect, careful consideration was given to the selection of features. After initial tests, a decision was made to restrict the analysis to boundaries. They form the largest and defining monument type for early fieldscapes, with widespread distribution and (relatively) consistent form. A data subset was created from the research categorisation layer and included all linear features types such as field boundaries, cultivation terraces, routeways and roads. Funerary and ritual monuments, areas of ridge and furrow, and settlement remains were excluded. The maximum spatial extent of the analysis was determined by the feature positioned at the furthest extent of the study area.

A requirement of Grouping Analysis is the definition of a spatial constraint that specifies how spatial relationships in the dataset are conceptualised and applied to constrain the creation of the groups. There is no standard technical principle for determining how these relationships should be expressed or consensus in the archaeological literature on the form they might take. Multiple runs of the data were undertaken to test the performance of the grouping solutions using different constraints. The first was k-nearest neighbour, with the neighbour parameters set to 0, 4, 8 and 12 neighbours. The second was an inverse distance weights matrix. Here, decay exponents of one and two were tested, each with 0, 4, 8 and 12 neighbours (the larger the exponent value, the quicker the weights depreciate as a measure of distance decay). A series of first, second and third order weight files were generated and tested before a final sequence involving the adoption of no spatial weight constraints. In this final component, features are not required to be near each other to be part of the same group. On testing, it became apparent that the adoption of a no spatial constraint framework was the most conceptually and technically appropriate solution given that the only two variables being included in the run were x,y locations (see also Martin et al. 2020). This meant that the addition of a spatial constraint was unnecessary and counterproductive as it would effectively amount to a double constraint of the grouping process based on spatial proximity.

The decision to adopt the no spatial constraint approach requires the user to define an initialisation method to establish the seed points that define the groups. In ArcGIS, the seeds can be determined by the user on conceptual grounds, chosen randomly by the algorithm, or based on a sample chosen by the algorithm that optimises the performance of the grouping process. In this case, there were no conceptual grounds on which to base the decision. When the seeds were chosen randomly by the algorithm there was no way to determine whether the random seeds were the optimal locations for the groups or whether these were creating suboptimal outcomes. On the surface, choosing to seed the groups in a way that optimised the grouping process appeared to be the logical choice. However, testing revealed that when the parameters for the grouping procedure are defined and executed for one run and then held constant and the process re-run again, the outcome of the grouping process would vary owing to differences in the choice of seeds between runs. Effectively, the optimality of the seed locations was specific to the run itself and not to the overall spatial distribution of the features themselves.

This limitation also extended to the decision for deciding the final number of groups that should be defined through the grouping process. As an unsupervised method, there are no consistent technical criteria for determining the optimal grouping solution. As part of the Grouping Analysis tool, a function exists to evaluate the optimum number of solutions between two and 15 groups. A pseudo F-statistic is computed and where no additional criteria are used to guide the choice as to what constitutes the optimal number of groups, then the solution that produces the largest pseudo F-statistic value is flagged as the optimal solution. The largest F-statistic values indicate solutions that perform best at maximizing both within-group similarities and between-group differences. By adapting the Python code in the tool script, it is possible to adjust the limit of the evaluation function beyond 15 groups but even so the determination of the optimal number of groups is also conditioned by the initialisation method needed to establish the seed points and itself conditions the 'randomness' of the seed initialisation.

Against these interlinked limitations, it was thought that an innovation could be introduced into the grouping process by defining seed locations *a priori*, as summarised in Table 6.8. This constrained the seeding process to those features where, using kernel density, peaks were identified in the concentration of the input features (*Figure 6.10*). The groups were then generated around the seeds based on the incorporation of x,y variables in the analysis fields. A Euclidean distance method was applied. The optimum solution was then mapped. Once the 'upper-tier' solution had been defined, the dataset was partitioned into new layers based on the individual groups. The process was then repeated for each individual upper-tier group. This generated a suite of 'lower-tier' solutions underlying each upper-tier group, providing added granularity and detail to the upper-tier grouping solution.

Boundary grouping results

The initial run of the data identified an 'upper-tier' grouping of boundaries based on the complete sample of 9,659 features. Using the seeding approach, the optimum number of groups was determined to be 13 and each of the 9,659 features were assigned to a single group. Based on the 13-group solution, the features were segmented into their individual groups. These upper-tier groups were then individually subjected to a second run in which the kernel process was re-run and new seeds identified before grouping analysis was used to generate a series of new grouping configurations that were combined to form a 'lower-tier' solution, as summarised in Table 6.9, and *Figure 6.11* and *Figure 6.12*. The total number of lower-tier groups varied between 3 and 19, each of which had as few as a small handful of features or several hundred. The total number of locally coherent groups was therefore more than 150, a far larger number than would be easy to recognise through simple visual inspection of the features.

Overlying the groupings with the original polygonal fieldscape data shows that they are good proxies for feature *coherence* rather than just feature numbers, providing a consistent basis for analysis at different scales and helping to identify areas with the greatest potential for more detailed study. The variation in density and extent is illustrated in *Figure 6.13*. Overlying the groupings with the RFH polygonal fieldscape data provided further information about the variation in preservation. Concentrations of well-preserved features, with an average RFH greater than 0.043m (medium, high and highest RFH), survived in 15 locations; less well-preserved features, with an average RFH greater than 0.017m (low RFH) survived in a further 49 locations; the remaining groups had poorly preserved features, with an average RFH of less than 0.016m (lowest RFH). The distribution of these groups is shown on *Figure 6.14*. The new geospatial datasets are detailed in Appendix L (Table L3).

Grouping Analysis for other monument types

The boundary grouping results can also be compared with the distribution of other early fieldscape monument types such as settlement remains, enclosures and clearance cairns. There are constraints: the number of features for these monuments (their sample size) is smaller and their identification from lidar models is variable, both factors reducing the interpretive value of further statistical analysis. Settlement remains are particularly difficult, as detailed in chapter 5, with many known examples where it was not possible to identify and transcribe features. The total number of enclosures, by contrast, increased through transcription from lidar and the failure rate for identifying known sites was lower. In the light of this, the enclosure subset was chosen as a test to explore the correlation between boundaries and other fieldscape features.

The enclosure subset (n=278) was run through the Grouping Analysis methodology to generate seeds. Six seeds were identified around which a single tier of groups was formed. These groups were then used to segment the 'enclosure' features into separate files but instead of running the grouping analysis again, an average Nearest Neighbour Index (NNI) was calculated for each group. Unlike the boundary feature data subset, enclosures are circular, sub-circular or roughly rectangular, and therefore calculations based on their centroid have greater interpretive value. Average NNI was calculated using average straight-line distance from each enclosure feature to its nearest neighbour. The furthest extent of features in each group determined the spatial extent of the analysis. An NNI score of less than one indicates that the pattern of enclosure features tended towards clustering, and when greater than one dispersion. An NNI closer to zero indicates a random distribution. This process enabled further interpretation of feature coherence where enclosures reflect patterning towards clustered coherence (tending towards 1), dispersed coherence (tending towards -1) and randomness (tending towards 0).

The results of the Average NNI for enclosures is outlined in Table 6.10. It shows meaningful clusters for five of the six groups, and random distribution for the remaining group. Visual comparison between the 'upper-tier' boundary groupings and enclosure groups shows that they are broadly correlated, as illustrated in *Figure 6.15*. It indicates two areas where the concentration of enclosures appears to be greater and where the NNI ratio confirms that clustering is strongest: along the north coast (enclosure cluster group 2) and south of Harlech (enclosure cluster group 3). These are groups with the highest number of observations and good lidar coverage. A third group (enclosure cluster group 4) also has a high NNI ratio in spite of a lower number of observations, but these features lie in an area with a large gap in the lidar coverage, where previous point record data suggests the survival of fieldscape features (see figure 5.22). This would appear to be an area with strong potential for the survival of more detailed fieldscape elements, such as enclosures.

Applying geostatistical approaches to assess the character of early fieldscapes

The concept of character has been used in this section to identify the qualities that are most relevant for understanding early land enclosure in Snowdonia, that is, what makes fieldscapes distinctive and interesting, and in what ways are they the same or different to others? They are questions that lie at the heart of field system studies elsewhere, in part because their recognition as coaxial, brickwork or aggregate field systems has *a priori* established them as well-preserved and coherent entities.

Morphological qualities such as field shape, size and orientation are the most common variables used in statistical analysis; other characteristics include the relationship of fields to slope and aspect, soil type, geology, land use and boundary type. Early applications of more sophisticated statistics for field systems using GIS include Wickstead's study of the Dartmoor reaves and her use of elevation, rainfall, slope and aspect as variables in statistical analysis (Wickstead 2007). More recently, Brown chose to focus on aspect and orientation, insolation and average annual rainfall intensity in her study of coaxial field systems in the Yorkshire Dales (Brown 2016).

As outlined in this chapter, the early fieldscapes dataset does not lend itself to statistical analysis for all these metrics, with imprecisions in field size and chronology being notable weaknesses. Two key characteristics were identified as having the greatest potential: (1) topographic setting, exploring the relationship between boundary orientation, aspect and slope and (2) field shape, distinguishing coaxial, aggregate (less regularly perpendicular field systems) and curvilinear enclosure patterns. The assessment of these characteristics has built on approaches developed by Chris Green and his analysis of field systems in England, which formed part of the wider *English Landscapes and Identities* (EngLaId) project (Gosden et al. In Press-a). This work involved examining forty field systems in detail from across England. The geospatial methods applied to these datasets depended on knowing the length and simplified shape of boundaries, best expressed in GIS as a polyline rather than a polygon object. The apparent simplicity of creating a standard measure for polygonal datasets is deceptive, with no readily available GIS tools or techniques to automate the process. Where boundaries had been digitised as polygon features rather than polylines, Green found that it was quicker and more accurate to create a new centre line for each original feature by individually digitising them (pers. comm), albeit he was working with datasets that had been created by different people, at different times and to varying standards.

The early fieldscape dataset for Snowdonia was not digitised with centre polylines denoting length and orientation, and a new approach was therefore needed to generate this measure. A semi-automated approach was developed to speed up its creation, as outlined in Table 6.3. The output from this process was then manually checked to identify errors. These typically included one or two nodes at the end of the main line and incorrect centre lines where boundaries crossed one another. The resulting 'cleaned' polyline boundary dataset formed the basis for analysing topographic setting and field shape.

Assessing topography

The mountainous topography of Snowdonia has inevitably influenced the layout of its early fields. Assessing the relationship between the two is not, however, straightforward: the irregular layout of boundaries makes their alignment difficult to measure and there are many potential topographic variables, as highlighted by recent efforts to fully standardize terrain features used in environmental and biodiversity modelling (Amatulli et al. 2018). An innovation for the early fieldscapes study was to take multiple measurements along boundaries to assess alignment. This detailed dataset was analysed in relation to aspect, slope and elevation, three key topographic variables chosen because of their simplicity and constancy over time.

(1) Measuring boundary alignment

Boundary alignment was measured by dividing each polyline into ten equal lengths and calculating an angle of orientation for each part (N=78534). The length and orientation variables were then pre-processed before analysis: the angle of orientation was divided into 16 alignment categories and the split boundary lengths normalised[78]. The boundary alignment categories were based on a 32-point compass because the boundaries do not have direction (two opposite points of the compass represent one alignment category). The split boundary lengths were normalised across the whole dataset using range standardisation: each variable was recalculated as (V - min V)/ (max V - min V), where V represents the split length of each boundary. The full methodology for calculating the angle of orientation and aspect is outlined in Table 6.11.

(2) Aspect

The 1m resolution DEM was used to calculate aspect for each 'split' boundary length, based on the cardinal and ordinal points of a compass (8 categories). The strength of association between boundary alignment and aspect was initially assessed using Kendall's Tau rank correlation[79]. The results indicated that there was significant weak negative association ($r(78532) = -.107$, $p < .001$). That is, there was a slight tendency for boundaries to be aligned perpendicular to aspect.

Whilst the correlation results are a useful guide to the association between boundary alignment and aspect, the distribution of values across these two variables provided a more detailed picture of their relationship. The tree chart and bar chart show the number of weighted boundaries for the principal facing slopes (*Figure 6.16*) and alignment category (*Figure 6.17*), calculated by multiplying the number of boundaries by the mean weighted index (min-max scaled dataset). This method allows comparison between boundaries of different lengths, giving greater weight to longer boundaries and less weight to shorter stretches. It shows that more than two thirds (69%) of boundaries are located on south, south-west or west facing slopes. Just under a third (27%) are on north or northwest facing slopes; only a tiny proportion (4%) are on north-east, east or south-east facing slopes. The preferred aspects have higher sunshine and lower wind strength and frequency.

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[78] IBM SPSS (Statistical Package for the Social Sciences) was used to carry out all pre-processing and statistical analysis for geospatial datasets

[79] The decision to use Kendall's Tau to test for correlation was based on the ordinal status of both variables and their ranking by orientation, calculated in a clockwise direction.

The distribution of boundary alignments across the eight aspect categories shows that there is strong tendency for boundaries to respect aspect, as indicated by the correlation test. The results are summarised in Table 6.12 and illustrated on the radar plot (*Figure 6.18*) and bar charts showing boundary alignment by principal facing slope (*Figure 6.19*, *Figure 6.20*). More boundaries are roughly perpendicular to aspect than parallel to it, but more significant is the consistent pattern of boundary orientations clustering within a very tight range (34 degrees) across all slopes. This pattern can be observed for the dataset as a whole and for the local clusters of high integrity features (*Figure 6.27*, *Figure 6.28*, *Figure 6.29*, *Figure 6.30*). Since these patterns have been identified through granular analysis across the sum of boundary lengths, their orientation is significant. Although the range of wind directions is influenced by microtopography in Snowdonia, the prevailing winds in the region today blow from directions between the south and northwest (Met Office 2016). Assuming this weather pattern has remained roughly constant over the last few thousand years, the boundaries on all principal faces are orientated to reduce their impact, offering the strongest protection from north-westerly, westerly, south-westerly and southerly winds.

(3) Slope and elevation

The 1m resolution DEM was used to calculate slope and elevation for each polygonal boundary, and the values joined to the polyline boundary dataset[80]. Kendall's Tau rank correlation[81] was used to test the strength of association between boundary alignment and the two variables. The results indicated that there was no relationship between alignment and slope ($r(78532) = -.009$, $p = .014$) and a significant weak relationship between boundary alignment and elevation ($r(78532) = -.013$, $p < .001$).

Assessing field shape

The irregularity of field boundaries in Snowdonia made it difficult to directly apply models developed by previous authors to analyse field shape, layout or the division of space. The approach adopted here has been developed primarily from Green's work on the EngLaId datasets (Gosden et al. In Press-a) and discussed below.

Field layout and division of space (i.e. field shape) were considered separately by Green using different statistical approaches, but insights from both have been used to develop an approach suited to Snowdonia's early fieldscapes. For the EngLaId datasets, field layout was analysed by measuring the orientation of boundaries, referred to as an 'Index of Coaxiality'. Strongly rectilinear

[80] Feature elevation attributes were joined to the polyline dataset using the Spatial Join tool in ArcGIS Analysis ArcToolbox.
[81] The decision to use Kendall's Tau to test for correlation was based on the ordinal status of boundary alignment and continuous variable status for slope and elevation.

or 'coaxial' patterns had bearings clustered around two approximately perpendicular values; less rectilinear layouts had weaker patterns of clustering and more distributed bearings. The index assumed that more regular (or coaxial) field systems have a strong central axis, with further field boundaries laid out at right angles. These two primary orientations would be expected to show as peaks of orientation when plotted on a graph (Gosden et al. In Press-a: chapter 7). The size and shape of fields was explored using a second technique, where three metrics were counted and then compared: the number of nodes, the number of lines and the total length of lines. More nodes per hectare were assumed to imply more changes of direction (i.e. curvier lines) and junctions between lines (and by extension more field boundaries). More lines and a greater length of lines per hectare were assumed to imply more changes of direction and more field boundaries.

The results from the EngLaId research suggest that the 'Index of Coaxiality' was the more successful of the two approaches. However, the difficulty of identifying a central axis for irregular field systems ruled out its application to the early fieldscapes dataset. Similarly, the accuracy of line and node density counts as a proxy for field shape and size was less convincing for field systems with irregular layouts, and the node-line density method was therefore not tested for Snowdonia. The principle of using a comparative index for boundaries and assessing changes in boundary direction were, however, ideas developed by focusing on the concept of *linearity*.

The degree to which the fieldscapes of Snowdonia had straight or curved boundaries was measured by comparing line length with the shortest distance between its start and end point. The methodology is outlined in Table 6.11 and follows similar approaches more commonly used to assess the sinuosity of rivers. To allow comparison between boundaries with differing lengths, the sinuosity index was normalised across the whole dataset using range standardisation: each variable was recalculated as (V - min V)/ (max V - min V), where V represents the value of the sinuosity index. This method allows variables to have differing means and standard deviations but equal ranges. Across the whole linear boundary dataset, there is at least one observed value at the 0 and 1 endpoints.

The normalised sinuosity index demonstrated variation across the upper tier clustered groupings, as illustrated in *Figure 6.21*, and *Figure 6.23*. Strongly curvilinear boundaries were more frequent in the southern part of the study area, along the coast from Harlech (area 12): a higher proportion of straight boundaries were identified along the northern coastal fringe of Snowdonia (areas 5 and 13). The other areas shared similar mean and range sinuosity, situated between these upper and lower values.

The relationship between sinuosity and elevation was tested by comparing mean sinuosity with mean elevation for each upper tier cluster. The results of the Pearson correlation indicated a weak negative association ($r(10) = -.13$, $p < .001$)[82], that is, sinuosity increased very slightly with elevation. As with the relative height analysis, patterning was more significant for localised groups. Twelve lower cluster groups have higher mean sinuosity than the whole dataset mean, as illustrated in *Figure 6.24* and *Figure 6.25*. Five of these groups are part of the Ardudwy upper tier cluster area, which had the highest area sinuosity measure. The others are drawn from three upper tier groups which had similar mean and range for sinuosity to each other, indicating significantly higher levels of sinuosity for specific, localised groups of features (*Figure 6.26*).

Localised and distinctive patterns were also observed in the distribution of boundary alignment and aspect for high sinuosity fieldscape clusters. The correlation test results showed consistent significant weak correlation (Table 6.13) but, like the full dataset (*Figures 6.17-6.18*), the distribution charts for boundary alignment and aspect show their relationship more clearly (*Figures 6.25-6.28*). Although the boundaries were predominantly built on south, south-west or west facing slopes, they have locally distinct boundary alignments that respect their specific topography.

Concluding comments

The geostatistical analysis presented in this chapter is based on several innovative approaches developed to help understand the early fieldscapes of Snowdonia. It focused first on understanding where fieldscapes are best preserved and most coherent, that is, where they have the greatest *integrity*. These results guided more detailed analysis of their field shape and setting, that is, their *character*.

The survival and coherence of features was assessed using two principal techniques: a measure for Relative Feature Height (RFH) and a grouping analysis method to assess clustering and proximity. The RFH was calculated for all individual transcribed features (n=13826) and for all categorised 'monuments' (N=10253), allowing analysis of both surviving feature type (form) and monument type. The results of the grouping analysis defined areas with higher feature coherence at a regional and local scale, based exclusively on the locational proximity of boundaries (n=9659). These upper (regional) and lower (local) tier boundary groups were compared with the distribution patterns for enclosures (n=278), showing that the two were correlated at a regional scale.

Overlying the groupings with the original polygonal fieldscape data shows that they are good proxies for feature coherence rather than just feature numbers, providing a consistent basis for analysis at different scales and helping to identify areas with the greatest potential for more detailed study. The analysis confirmed that the most densely populated and well-preserved features are found along the

[82] Parametric validity was tested for sinuosity and elevation, using the paired t-test. The results showed that they were parametric ($t(11) = 11.13$, $p < .001$).

north coast above Llanfairfechan, and to the south between Harlech and Barmouth. It also indicated that the best-preserved features survived in 15 localised areas, some outside these two regional foci. Preservation, feature density and heterogeneity were all considered during the selection of specific areas for more detailed analysis to assess character.

Careful consideration was also given to choosing the qualities and corresponding variables that were most suitable for assessing character. Two key characteristics were identified as having the greatest potential: (1) topographic setting, exploring the relationship between boundary orientation, aspect and slope and (2) field shape, distinguishing coaxial, aggregate (less regularly perpendicular field systems) and curvilinear enclosure patterns. To aid this analysis, a new, semi-automated approach was developed to create a centre polyline for all polygonal boundaries. Each polyline was split into 10 and the angle of orientation was calculated for each part (N=78534). The results were used to compare boundary alignment with aspect.

The analysis of topographic setting showed that more than two thirds of boundaries are located on south, south-west or west facing slopes. Just under a third are on north or northwest facing slopes. Boundary alignment was strongly associated with aspect, with a consistently narrow range of orientation across all slopes. They were predominantly built perpendicular to the slope on south and north facing slopes; and were predominantly parallel to the slope on south-west facing slopes. On west and northwest facing slopes they were neither strongly parallel nor perpendicular to the slope. No relationship was identified between the angle of boundary slope (i.e. how steep a boundary was) and aspect. There was a significant weak relationship between boundary alignment and elevation.

Field shape was assessed by focusing on the degree to which the fieldscapes of Snowdonia had straight or curved boundaries. A comparative index was developed, adapted from similar approaches commonly used to assess the sinuosity of rivers. This demonstrated regional and local variations in boundary shape. Strongly curvilinear boundaries were more frequent in the southern part of the study area, along the coast from Harlech: a higher proportion of straight boundaries were identified along the low-lying northern coastal fringe of Snowdonia. There was a very slight increase in sinuosity with elevation.

These results demonstrate how high-quality data collection and new geostatistical methods can make a major contribution to understanding early fieldscapes. They indicate that early enclosure took place in areas with higher levels of sunlight, and that the shape and location of boundaries reduced the impact of prevailing winds. Below 350m, these factors had a stronger influence on enclosure than elevation. The relatively high sinuosity for all boundaries, which was more pronounced at higher altitudes, appears to reflect a deliberate and knowledgeable process of land division that responded to the varied microtopography of the region.

Table 6.1

Selected feature attributes with potential for geostatistical analysis

*Variables are categorical (discrete/qualitative) or continuous (quantitative). Categorical variables can be further divided into nominal variables (two or more categories, no intrinsic order), dichotomous variables (only two categories) and ordinal variables (two or more categories that can be ranked or ordered). Continuous variables can be divided into interval variables (numerical values along a continuum) and ratio variables (interval with the condition that where there is none it can be represented by '0')

Fieldscapes dataset name	Variable (Attribute field name)	Variable type*	Value of variable to answer key research questions:			
			Geographic distribution	Preservation	Form and cohesion	Temporality
Transcription	Feature type	Nominal categorical variable with 13 categories	HIGH	HIGH	HIGH	LOW
	Area	Continuous interval variable	HIGH	HIGH	HIGH	LOW
	Positional accuracy	Ordinal categorical variable with 7 categories	LOW	MEDIUM	LOW	LOW
	Digitising scale	Ordinal categorical variable with 3 categories	LOW	MEDIUM	LOW	LOW
	Field visit recommended	Dichotomous categorical variable	LOW	LOW	LOW	LOW
Research Categorisation	Monument	Nominal categorical variable with 24 categories	HIGH	HIGH	MEDIUM	MEDIUM
	Period	Nominal categorical variable with 13 categories	HIGH	LOW	MEDIUM	MEDIUM
	Dating type	Nominal categorical variable with 7 categories	LOW	LOW	MEDIUM	MEDIUM
	Field visit completed	Dichotomous categorical variable	LOW	MEDIUM	LOW	MEDIUM
Cultivation marks	Length	Continuous interval variable	HIGH	HIGH	HIGH	MEDIUM

Table 6.2

Selected context variables with analytic potential

*Variables are categorical (discrete/qualitative) or continuous (quantitative). Categorical variables can be further divided into nominal variables (two or more categories, no intrinsic order), dichotomous variables (only two categories) and ordinal variables (two or more categories that can be ranked or ordered). Continuous variables can be divided into interval variables (numerical values along a continuum) and ratio variables (interval with the condition that where there is none it can be represented by '0')

** These are raster datasets, suitable for descriptive rather than analytical analysis in their current form

GIS resource description dataset name	Variable (Attribute field name)	Variable type*	Value of variable to answer key research questions:			
			Geographic distribution	Preservation	Form and cohesion	Temporality
Ordnance Survey mapping	OS terrain 5	Continuous interval variable	HIGH	HIGH	MEDIUM	LOW
	OS Terrain 50	Continuous interval variable	MEDIUM	MEDIUM	LOW	LOW
Met office (CEDA Archive)	MIDAS solar radiation data	Continuous interval variable	MEDIUM	LOW	MEDIUM	LOW
Composite lidar dataset	Lidar surface and terrain models	Continuous interval variable	HIGH	HIGH	MEDIUM	LOW
Index to lidar coverage	Lidar coverage at 1m resolution	Dichotomous categorical variable (present or absent)	LOW	HIGH	LOW	LOW
British Geological Survey	Geology	Ordinal categorical variable, with some continuous interval attributes (e.g. area)	MEDIUM	MEDIUM	MEDIUM	LOW

GIS resource description dataset name	Variable (Attribute field name)	Variable type*	Value of variable to answer key research questions:			
			Geographic distribution	Preservation	Form and cohesion	Temporality
British Geological Survey	Soil Parent	Ordinal categorical variable, with some continuous interval attributes (e.g. area)	HIGH	HIGH	HIGH	LOW
	Superficial Deposit thickness	Ordinal categorical variable, with some continuous interval attributes (e.g. area)	MEDIUM	HIGH	MEDIUM	LOW
Centre for Ecology and Hydrology	Land cover data	Ordinal categorical variable, with some continuous interval attributes (e.g. area)	MEDIUM	HIGH	MEDIUM	LOW
Met Office	Rainfall	Ordinal categorical variable, with some continuous interval attributes (e.g. area)	MEDIUM	LOW	MEDIUM	LOW
Medieval field systems, 2015	Survey area	Continuous interval variable	MEDIUM	HIGH	LOW	LOW
	Transcription from lidar	Nominal categorical variable	MEDIUM	HIGH	MEDIUM	MEDIUM
	Transcription from 1st edition Ordnance Survey maps	Nominal categorical variable	MEDIUM	MEDIUM	LOW	MEDIUM
Medieval field systems, 2015	Transcription from aerial photographs	Nominal categorical variable	MEDIUM	HIGH	MEDIUM	MEDIUM
Radiocarbon dates	Detailed information on all radiocarbon dates	Nominal categorical variable (some ordinal potential)	LOW	LOW	MEDIUM	HIGH

GIS resource description dataset name	Variable (Attribute field name)	Variable type*	Value of variable to answer key research questions: Geographic distribution	Preservation	Form and cohesion	Temporality
RCAHMW upland survey, 2003-2014	Survey area	Ordinal categorical variable	MEDIUM	MEDIUM	MEDIUM	LOW
Early RCAHMW surveys**	Mapped features	Ordinal categorical variable	MEDIUM	MEDIUM	MEDIUM	LOW
	Original survey areas	Continuous interval attribute	MEDIUM	MEDIUM	MEDIUM	LOW
Early fieldscapes	Concordance with PRN (attribute field, research categorisation)	Ordinal categorical variable (with dichotomous variable potential i.e. present or absent)	LOW	LOW	LOW	LOW
Early fieldscapes	Concordance with NPRN (attribute field, research categorisation)	Ordinal categorical variable (with dichotomous variable potential i.e. present or absent)	LOW	LOW	LOW	LOW
Monument data	Scheduled monument polygonal dataset	Ordinal categorical variable, with some continuous interval attributes (e.g. area) and some nominal categorical variables (e.g. period)	LOW	HIGH	LOW	LOW
	NMR point data (NPRN)	Ordinal categorical variable, with some nominal categorical variables (e.g. period)	LOW	HIGH	HIGH	MEDIUM
	HER point data (PRN)	Ordinal categorical variable, with some nominal categorical variables (e.g. period)	LOW	HIGH	HIGH	MEDIUM
Monument data	HER spatial dataset for Roman Roads	Nominal categorical variable	MEDIUM	HIGH	HIGH	MEDIUM

Table 6.3
Approach for creating a polyline dataset from polygonal linear features[83]

Outcome	Process, workflow and use of geospatial tools
New polygonal dataset created for linear features, combining original polygon extent and 0.5m buffer	Use of standard ArcGIS ArcToolbox Analysis tools to create 0.5m buffer for polygon features. Creation of new dataset joining buffer and features, including a binary attribute field to recode all buffers as '0' and all original polygons as '1'.
Rasterised linear feature dataset	Use of standard ArcGIS ArcToolbox Conversion 'Feature to Raster' tool to convert linear polygonal dataset to raster dataset based on a cell size of 0.25m. The raster surface output for each feature was converted to a binary output that distinguished buffers from the original features.
Centrelines generated for rasterised linear feature dataset (first run)	Use of standard ArcGIS ArcToolbox to create a new polyline feature class. Use of standard ArcGIS ArcScan vectorisation function to generate centrelines for rasterised features.
Vectorisation settings optimised through iterative testing	The geometrical intersection was adopted with a maximum line width set to 100. The noise level was adjusted between 65 and 80 depending on the feature sample. The compression tolerance was tested but the default 0.025 was retained as was the smoothing weight of 3. The buffers allow ArcScan to generate vectors because it is able to distinguish (toggle) between the foreground and the background. Centrelines can be generated for both but there needs a contrast for the approach to run. The foreground in this case was the original features and the background (only visible at the edge of the features) were chosen as the background.
Linear feature centreline dataset created (final run)	Quality control on final dataset, identifying and discarding a small minority of raster features where it was not possible to generate centrelines because the shape was closer to a square or rectangle than a linear.

[83] This was undertaken using the University of Sheffield's Faculty of Social Science Poweredge Computer (360GB).

Table 6.4
Relative Feature Height (RFH) methodology

Outcome	Process, workflow and use of geospatial tools[84]
Seamless 1m DEM created for the whole study area	Use of standard ArcGIS ArcToolbox Data Management mosaic dataset tools to create a seamless 1m DEM from the composite lidar data (1m resolution) downloaded from the Geo-Portal for Wales (http://lle.gov.wales/home).
Rasterised dataset for transcription and research categorisation layers	Use of standard ArcGIS Toolbox Conversion 'Polygon to Raster' tool to convert transcription and research categorisation polygonal datasets to rasterised datasets.
Relative elevation calculations for rasterised transcription and research categorisation datasets, using a neighbourhood cell value of 3x3m	Use of the Relief Analysis Toolbox, an open source ArcGIS resource developed by Miller (2014), to calculate relative elevation for rasterised transcription and research categorisation layers. Using the 1m DEM, relative elevation was calculated on a neighbourhood-by-neighbourhood basis for each cell. A *reference elevation ceiling* is calculated by summing the neighbourhood minimum and maximum elevations. The *central cell elevation* is subtracted from the *elevation ceiling* to calculate an *inverse elevation*. By subtracting the inverse from the original elevation, a relative elevation grid is created with the midpoint between the neighbourhood minimum and maximum having a value of zero. (Miller 2014: 168) The outcome was a 1m raster grid that recorded increasing positive values above and decreasing negative values below the neighbourhood's mid-point elevation. Adjusting this neighbourhood value (e.g. to 5x5m or 1x1m) impacts the outcome. The 3x3m neighbourhood was determined through iterative testing and comparison using visual inspection of outputs against known features.
Summary statistics extracted from rasterised to polygonal transcription (n=13758) and research categorisation (N=10253) datasets	Use of standard ArcGIS Toolbox Spatial Analyst 'Zonal Statistics' tool to extract summary descriptive statistics for each digitised feature.

[84] This was undertaken using the University of Sheffield's Faculty of Social Science Poweredge Computer (360GB).

Table 6.5
Context variables and categories used to assess feature survival

Variable	Derivation of categories from mean Relative Feature Height (RFH) values (m)
Feature: attribute field from the *Transcription* dataset for Early Fieldscapes of Snowdonia. Sub-types: bank; lynchet; flattened wide bank; area of cultivation ridges; mound; pit; ditch; hollow; wall; structure; and scree bank. Monument: attribute field in the *Research Categorisation* dataset for Early Fieldscapes of Snowdonia. Sub-types and groups of sub-types as outlined in chapter 5: Prehistoric, funerary and ritual monuments; early field boundaries; early cultivation terraces; enclosures; hillforts; forts; roundhouse settlement remains; early settlement remains; roads and routeways; long houses; area of ridge and furrow; burnt stone mounds; clearance cairns; cairnfield; and cairns.	LOWEST mean Relative Feature Height: corresponds with mean relative height between -0.247 and 0.016 LOW mean Relative Feature Height: corresponds with mean relative height between 0.017 and 0.043 MEDIUM mean Relative Feature Height: corresponds with mean relative height between 0.044 and 0.080 HIGH mean Relative Feature Height: corresponds with mean relative height between 0.081 and 0.144 HIGHEST mean Relative Feature Height: corresponds with mean relative height between 0.145 and 0.627 NEGATIVE mean Relative Feature Height corresponds with a mean relative height less than 0 POSITIVE mean Relative Feature Height corresponds with a mean relative height greater than 0

Table 6.6
Comparison of RFH and feature elevation between scheduled and unscheduled sites, and recorded and unrecorded sites

Feature status	Final number of obs.	Mean *mean* RFH (m)	Max *mean* RFH (m)	Mean *max* RFH (m)	Max *max* RFH (m)
Transcribed feature within scheduled area	2,248	0.05	0.71	0.23	2.19
Transcribed feature outside scheduled area	11,578	0.03	0.63	0.18	2.03
Categorised feature within scheduled area	1,632	0.04	0.35	0.21	2.19
Categorised feature outside scheduled area	8,525	0.03	0.63	0.17	1.97
Categorised feature with national or regional record	2,032	0.04	0.35	0.22	2.19
Categorised feature with no national or regional record	8,125	0.03	0.63	0.16	1.97

Table 6.7
Comparison of RFH and feature elevation between boundary types

Boundary type	Final number of obs.	Mean *mean* RFH (m)	Mean *max* RFH (m)	Mean *mean* feature elevation (m)	Mean *max* feature elevation (m)	Mean *min* feature elevation (m)
Lynchet	837	0.03	0.19	180	182	178
Flattened wide bank	2,420	0.09	0.10	108	110	106
Bank	7,450	0.04	0.21	196	198	194

Table 6.8
Methodology used to define seeds

Outcome	Process, workflow and use of geospatial tools
Centroid (point) dataset created for Research Categorisation subset	Use of standard ArcGIS ArcToolbox Data Management 'Feature to Point' tool to generate centroid with x and y coordinates used in grouping analysis.
Tessellation grid generated as squares for study area	Use of standard ArcGIS ArcToolbox Data Management 'Generate Tessellation' tool to extend the study area limits beyond the individual features to minimise the impact of interpolation 'edge effects'.
Kernel density calculated for per-unit density of point features	Use of standard ArcGIS ArcToolbox Spatial Analyst 'Kernel Density' tool to calculate a per-unit density of point features. In ArcGIS, the function exists to weight the kernel by a population field. This field was left blank. The output cell size was defined automatically using the default where the cell size is defined as the shorter of the width or height of the output extent in the output spatial reference, divided by 250. Effectively this means that if the process is run on sub-samples of data, the cell size will be allowed to vary as the extent and scale of the feature density varies. No additional search radius was included as there was no conceptual or technical reason for doing so. The area measure was set to hectares, the output values were set to represent the predicted density value, with a geodesic (rather than planar) method applied.
Contours generated from output kernel density surfaces	Use of standard ArcGIS ArcToolbox Spatial Analyst tool 'Contour with Barriers' tool to generate contours for the output kernel densities surfaces' at a distance of 0.01m from a base contour of '0' and a z-factor of 1. The contours were generated at fine scales in order to define tight 'peaks' in the kernel surface (*Figure 6.9*).
'Peak' point identified from kernel densities	Manual selected of peaks from the kernel surfaces and export as a new layer. Use of standard ArcGIS Toolbox Cartography and Conversion tools to convert into polygons and subsequently into points.
'Seeds' defined by feature proximity to 'peak'	Use of standard ArcGIS ArcToolbox Analysis 'Generate Near Table' tool to identify (using the geodesic method) the closest point feature in the original dataset to each of the 'peak' points in the kernel density surface. Those features that were located closest to each 'peak' were defined as a 'seed' to be used in the grouping analysis.

Table 6.9
Results of Grouping Analysis

Upper tier group number	Number of points	Number of points as % of total	Number of lower tier groups
1	405	4.2%	8
2	79	0.8%	3
3	1322	13.9%	15
4	730	7.7%	13
5	553	5.8%	15
6	1011	10.6%	19
7	762	8.0%	15
8	547	5.7%	10
9	630	6.6%	14
10	821	8.6%	16
11	303	3.2%	4
12	1799	18.9%	15
13	575	6.0%	8

Table 6.10
Nearest Neighbour Index (NNI) for Enclosures

Cluster group number	Final number of obs.	Observed mean distance (m)	Expected mean distance (m)	NNI ratio	*Z*-score	*p*-value	Summary
1	48	426.18	753.68	.56	-5.76	< .001	clustered
2	62	449.19	825.28	.54	-6.85	< .001	clustered
3	89	311.91	822.79	.38	-11.21	< .001	clustered
4	35	242.87	591.39	.41	-6.67	< .001	clustered
5	23	438.99	797.49	.55	-4.12	< .001	clustered
6	23	731.73	832.56	.88	-1.11	.27	random

* An NNI score of less than 1 indicates that the pattern of enclosure features tended towards clustering, and when greater than 1 dispersion; an outlier analysis was undertaken but their effect on the final values was too small to warrant their removal.

Table 6.11

Methodologies for measuring orientation, aspect and sinuosity for boundaries

Outcome	Process, workflow and use of geospatial tools
Angle of orientation created for polyline dataset[85]	Points were generated along each of the centre polylines (snapped to 0.1m) using the 'Generate Points along Lines' tool in ArcGIS. The points were generated using a percentage parameter, where intervals were set to 10% of the total line length. Using the 'Split line at point' tool in ArcGIS, each of the polylines were split into 10 segments based on 10% intervals of the total line length. Using the 'linear directional mean' tool in ArcGIS, the mean direction of each of the line segments was calculated. The outputted compass angle (clockwise from due north) was classified into eight cardinal categories (N, NE, E, SE, S, SW, W, NW) using a bespoke python script.
Aspect calculated for polyline dataset[86]	Use of split polyline dataset created above. Use of standard ArcGIS ArcToolbox Spatial Analyst 'Extract by Mask' to extract values for boundary dataset from the 1m DEM, to limit data handling. Average for raster point to nearest line on the assumption it was an average. Compass direction that the downhill slope faces for each location (average, minimum, maximum, variation and standard deviation).
Sinuosity index created for polyline dataset	Use of standard ArcGIS ArcToolbox 'Minimum Bounding Geometry' tool to calculate minimum distance from start of polyline (a) and end of polyline (b), selecting 'circle' as the geometry type and using 'Calculate Fields' to generate diameter length. Use of standard ArcGIS ArcToolbox Data Management 'Calculate Fields' tool to create a value using the formula: Sinuosity ratio = actual polyline length/ minimum polyline length (circle diameter) A straight line will have a sinuosity index of 1, a curved line will have a score closer to 0.

[85] This was undertaken using the University of Sheffield's Faculty of Social Science Poweredge Computer (360GB).

[86] This was undertaken using the University of Sheffield's Faculty of Social Science Poweredge Computer (360GB).

Table 6.12
Summary of principal facing slopes and the alignment of boundaries

Facing slope (percentage of total)	Boundary alignment
West (24%)	All boundaries are orientated across five of the sixteen alignments, with a maximum range of 56 degrees. More than two-thirds (77%) are orientated across three alignments (within 34 degrees), centred on a northeast-southwest axis (which is neither parallel nor perpendicular to slope), with larger proportion tending towards being perpendicular to the slope. Would provide strongest protection from north-westerly and westerly winds.
South-west (24%)	All boundaries are orientated across five of the sixteen alignments, with a maximum range of 56 degrees. Most boundaries (87%) are orientated across three alignments (within 34 degrees), centred on a northwest-southeast axis parallel to the slope. Would provide strongest protection from west and south-westerly winds.
South (21%)	All boundaries are orientated across five of the sixteen alignments, with a maximum range of 56 degrees. More than two-thirds (77%) are orientated across three alignments (within 34 degrees), centred on a north-south axis perpendicular to the slope. Would provide strongest protection from northwest, west and south-westerly winds.
North (16%)	All boundaries are orientated across five of the sixteen alignments, with a maximum range of 56 degrees. Just under two thirds (64%) are orientated across two alignments (within 23 degrees), centred on an east-west axis perpendicular to the slope. Would provide strongest protection from northwest to north-easterly winds.
Northwest (11%)	All boundaries are orientated across five of the sixteen alignments, with a maximum a range of 56 degrees. Most boundaries (88%) are orientated across three alignments (within 34 degrees), centred on an east by northwest by south axis (which is neither parallel nor perpendicular to slope), with a larger proportion tending towards being perpendicular to the slope. Would provide strongest protection from north and north-easterly winds.

Table 6.13

Correlation of boundary alignment (based on 32-point compass) and DEM aspect (based on 8-point compass)

Group reference (letter is cluster)	***N*** *n*	Kendall's tau correlation coefficient	*p*-value
ALL	78534	-.107**	< .001
a	852	-.137**	< .001
b	1631	-.096**	< .001
c	25	-.004	.979
d	221	-.061	.256
e	1865	-.124**	< .001
f	360	-.068	.084
g	1461	-.133**	< .001
h	1230	-.115**	< .001
i	2529	-.059**	< .001
j	1410	-.093**	< .001
k	1437	-.076**	< .001
L	2697	-.095**	< .001

** Correlation is significant at the 0.05 level (2-tailed)

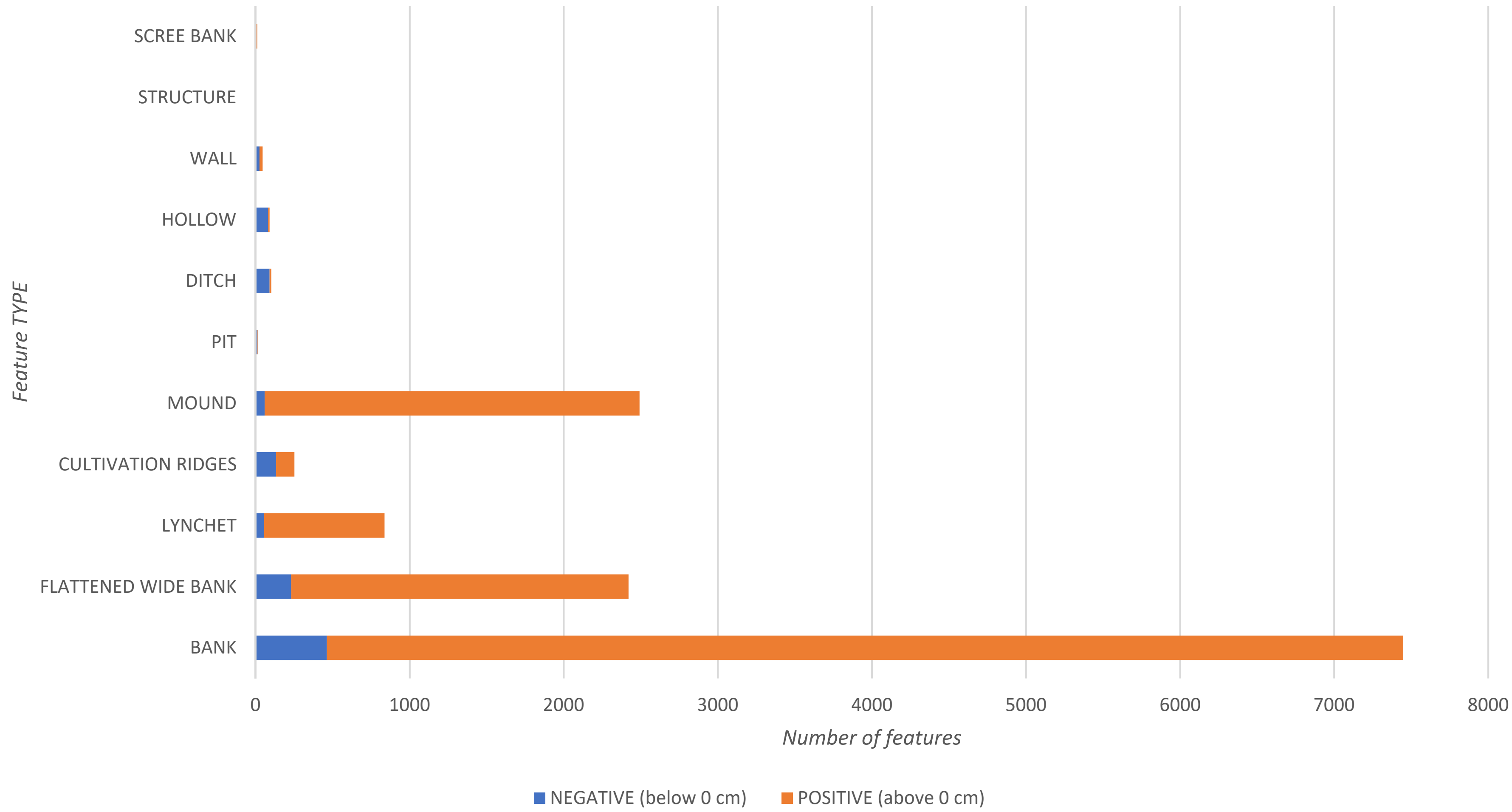


Figure 6.1
Distribution of mean Relative Feature Height (RFH) by feature type
The small number of negative values for banks and mounds is because RFH is a proxy for height not an absolute measure and there may be errors with the spatial extent and/or feature recognition. For a full explanation see the discussion of RFH above.

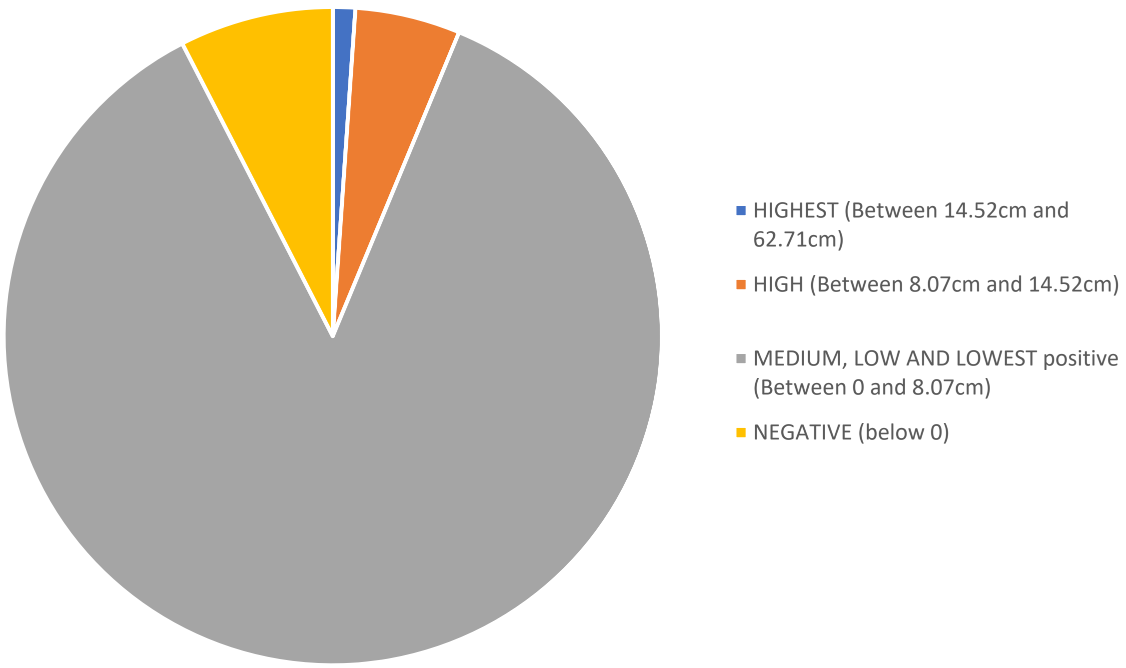


Figure 6.2
Distribution of mean Relative Feature Height (RFH) across all monument types

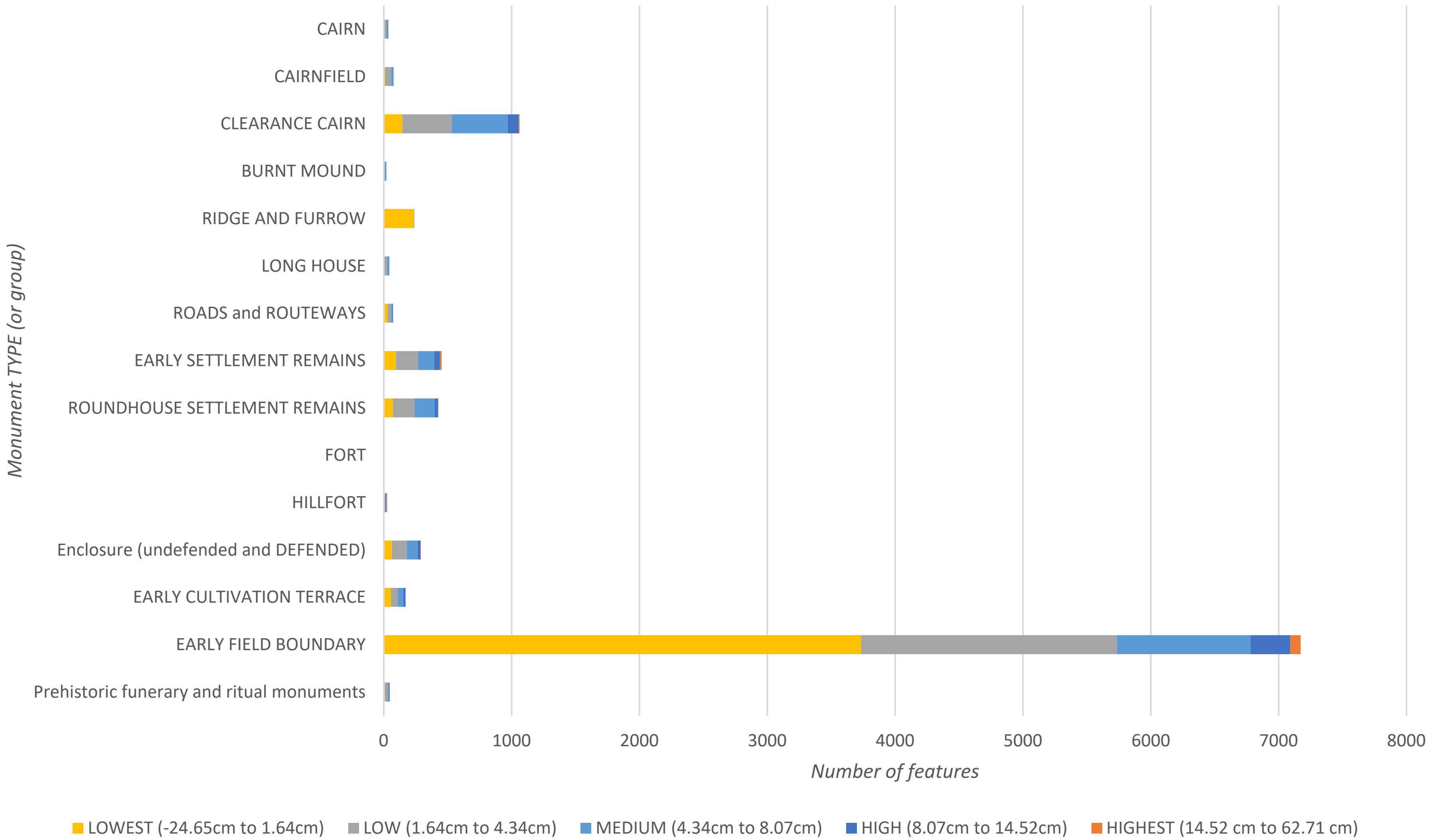


Figure 6.3
Distribution of mean Relative Feature Height (RFH) by monument type

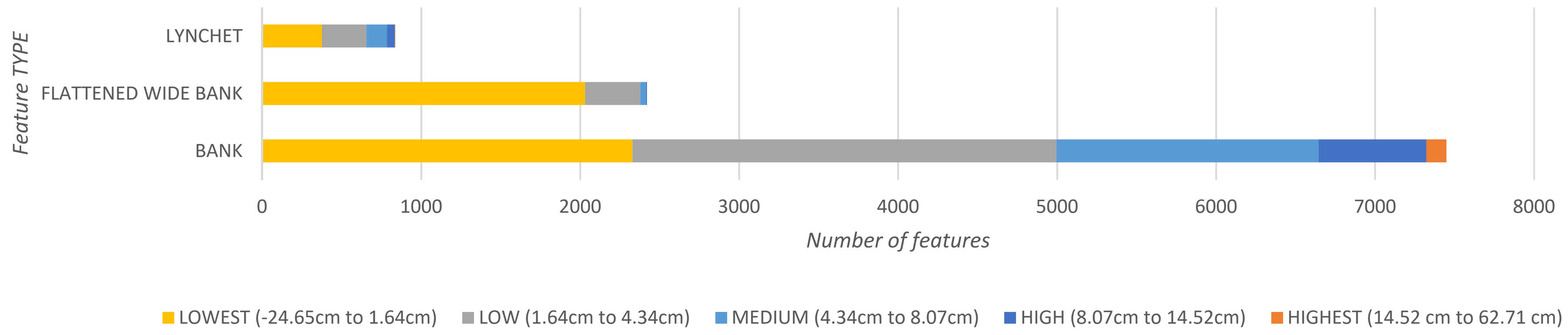


Figure 6.4

Distribution of mean Relative Feature Height (RFH) by boundary feature type

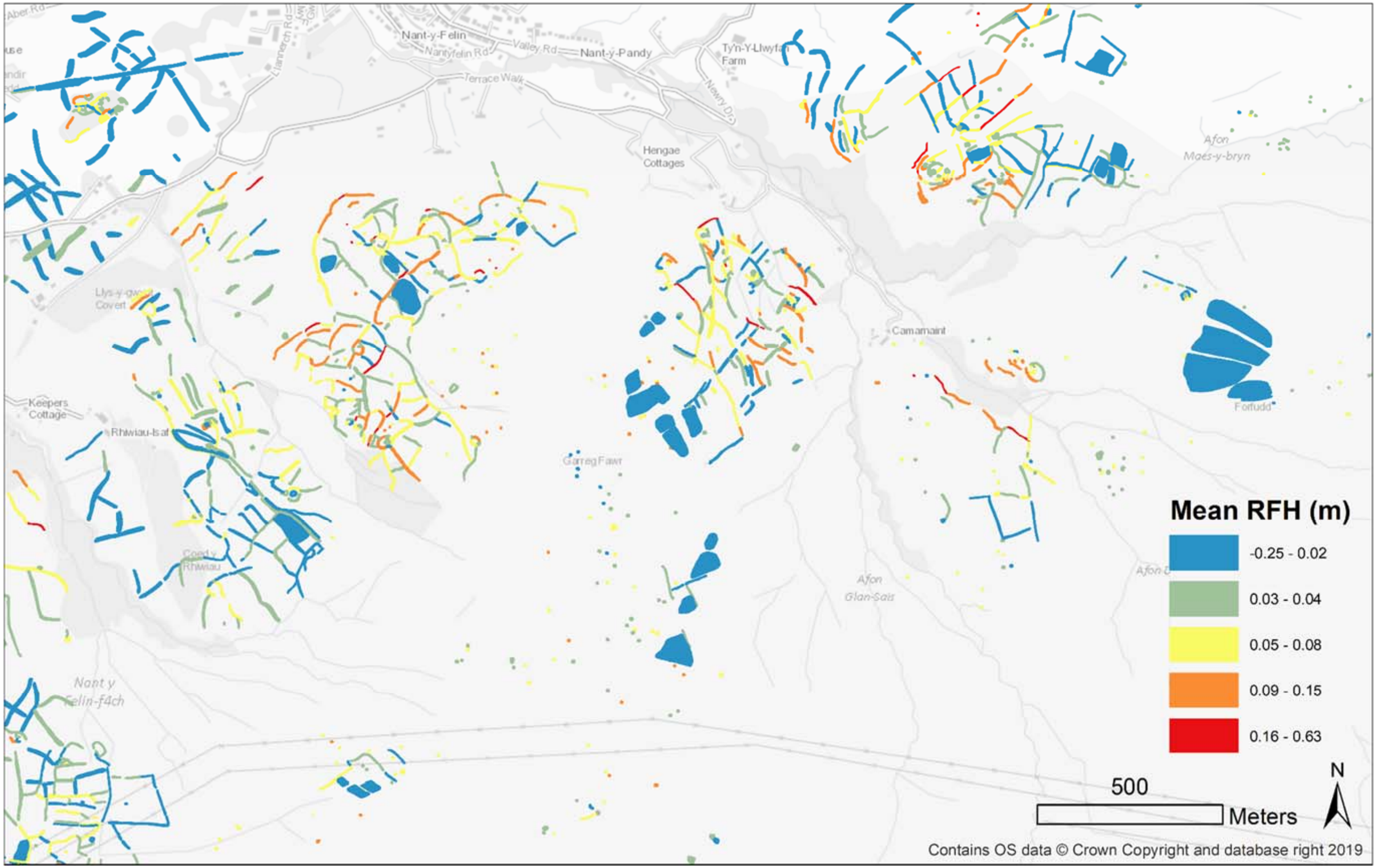


Figure 6.5
Mean RFH, uplands above Llanfairfechan, shown at 1:15,000

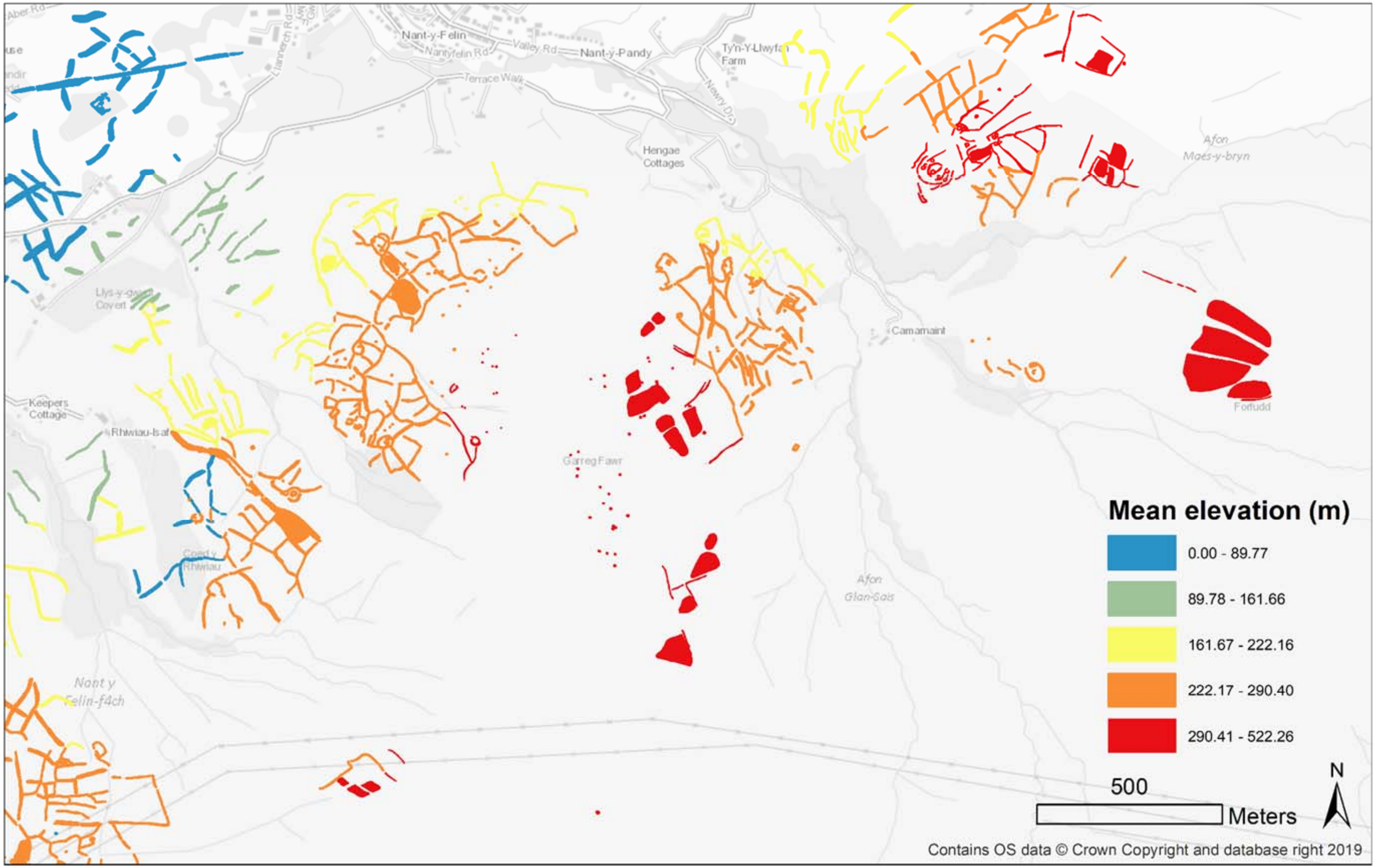


Figure 6.6
Mean feature elevation, uplands above Llanfairfechan, shown at 1:15,000

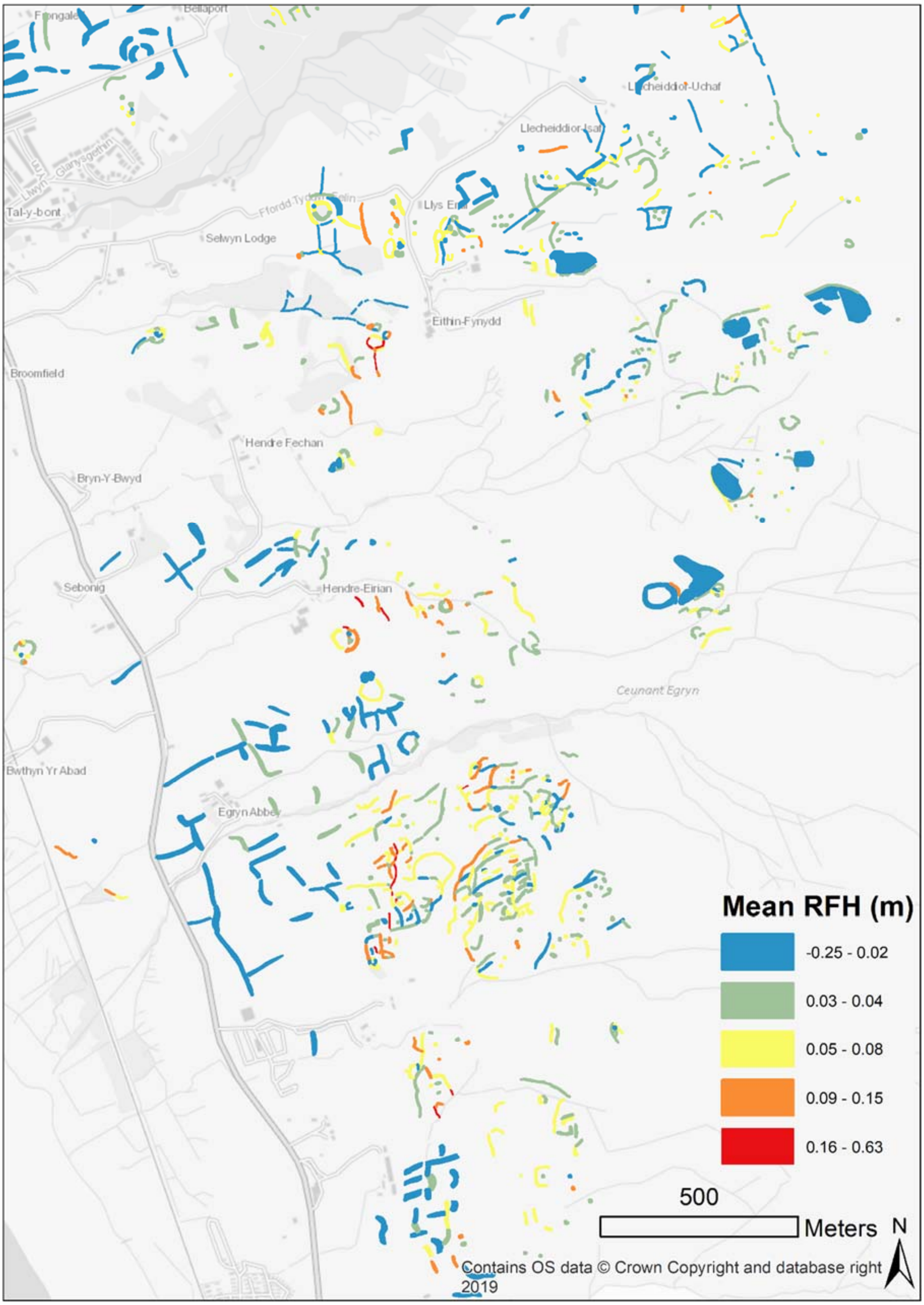


Figure 6.7
Mean RFH, uplands above Ardudwy, shown at 1:15,000

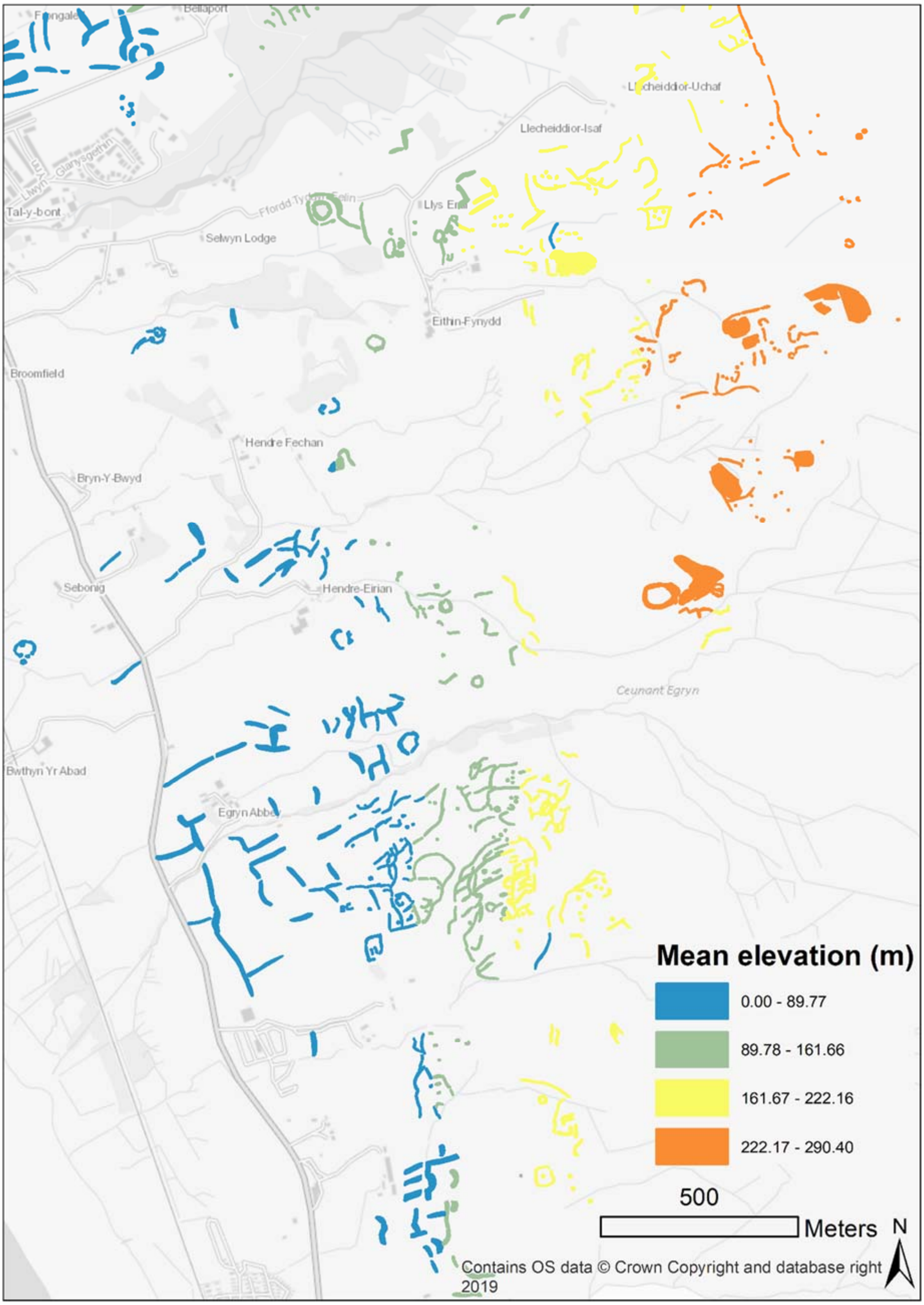


Figure 6.8
Mean feature elevation, uplands above Ardudwy, shown at 1:15,000

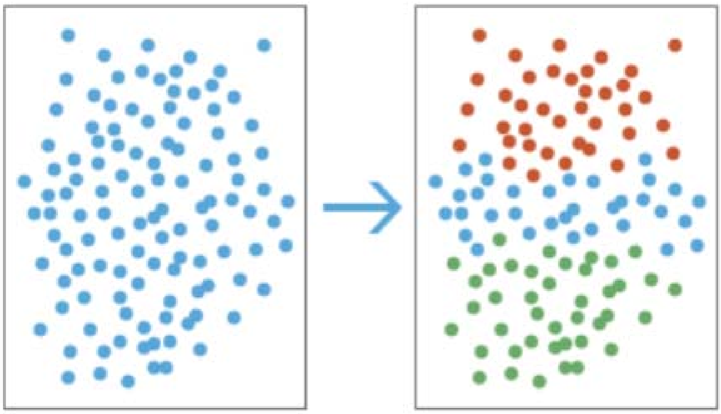


Figure 6.9
Grouping Analysis feature separation

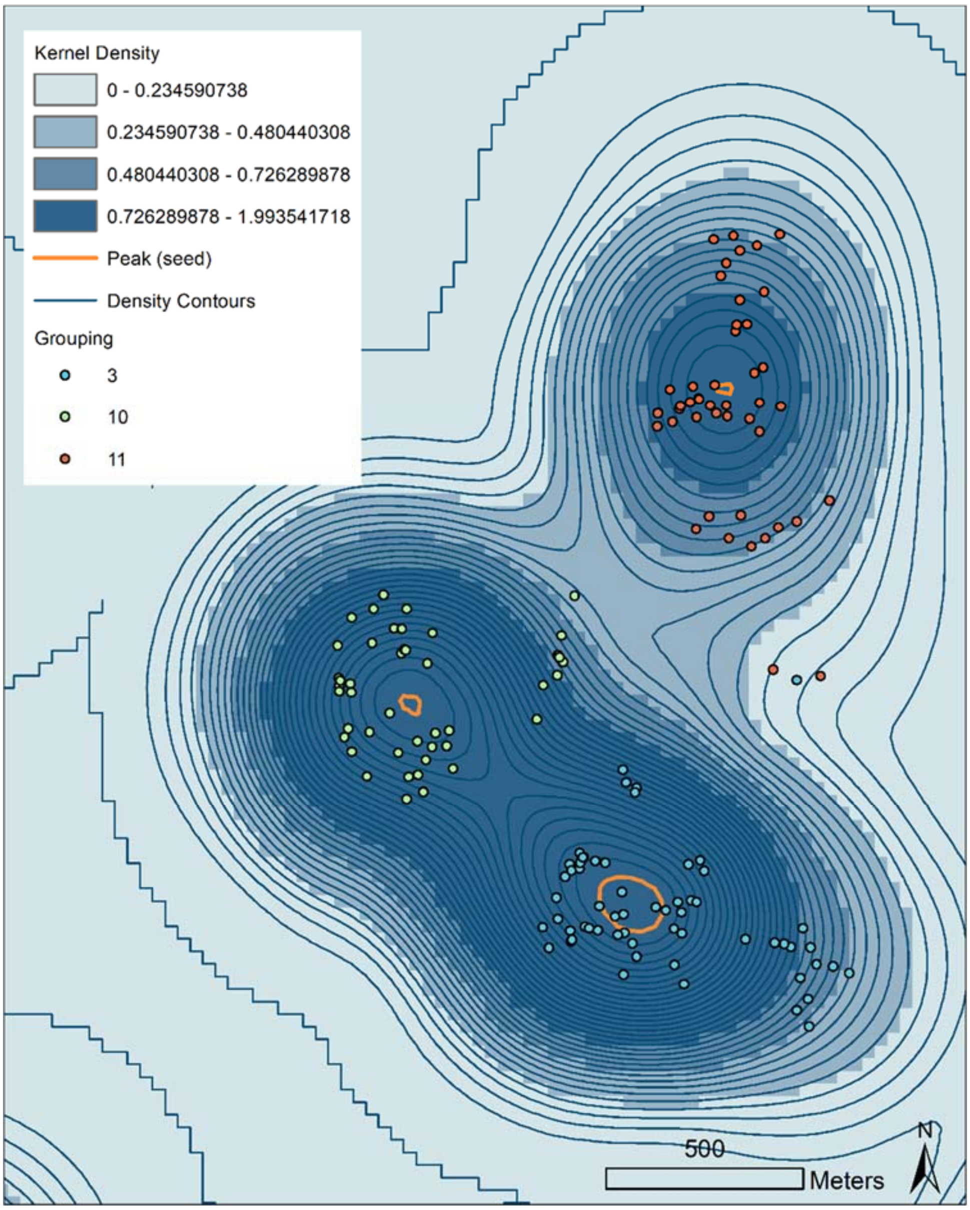
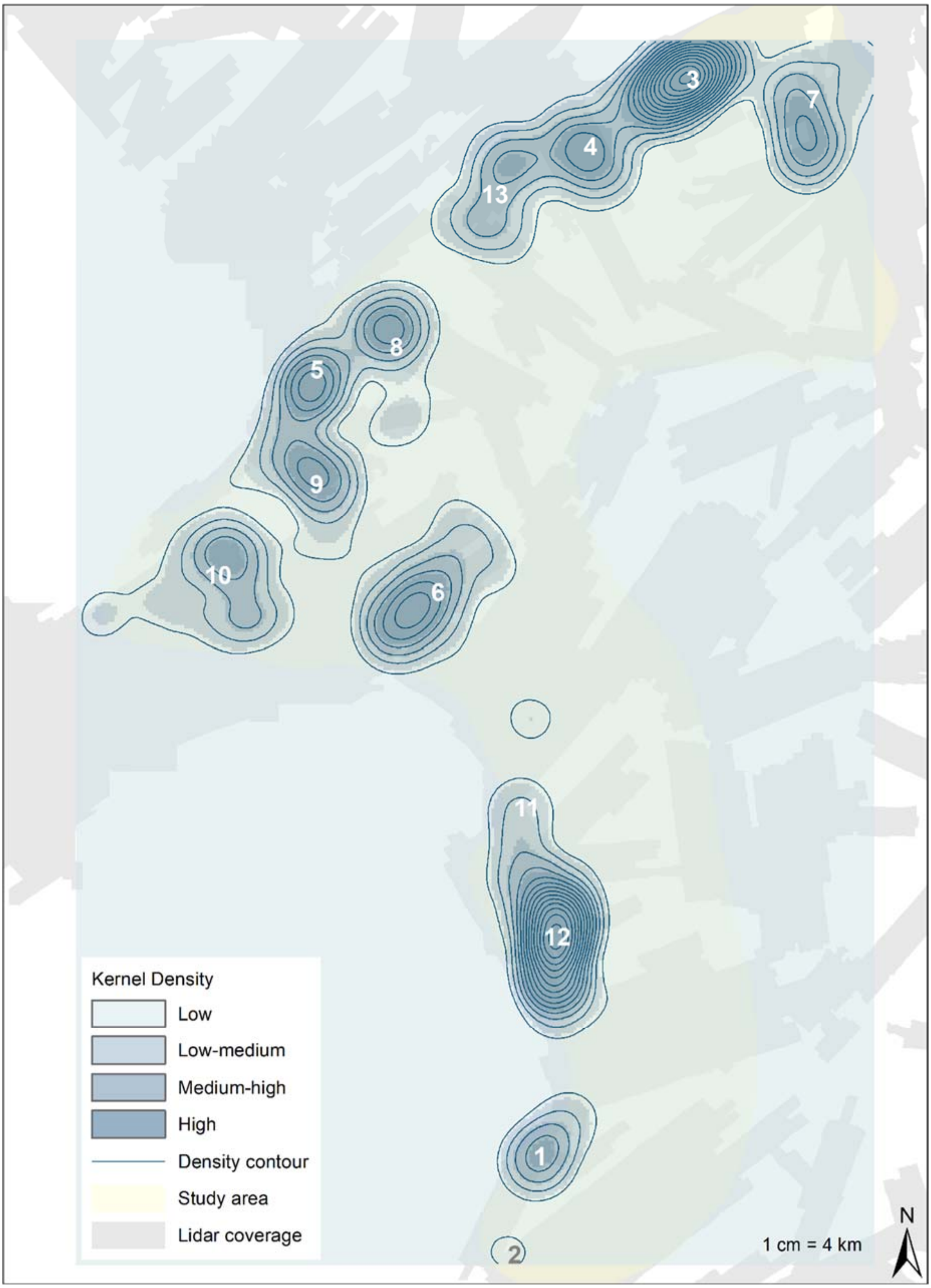


Figure 6.10
Kernel density illustrating lower tier seeds and groupings

Figure 6.11



Upper tier groupings, shown at 1:350,000

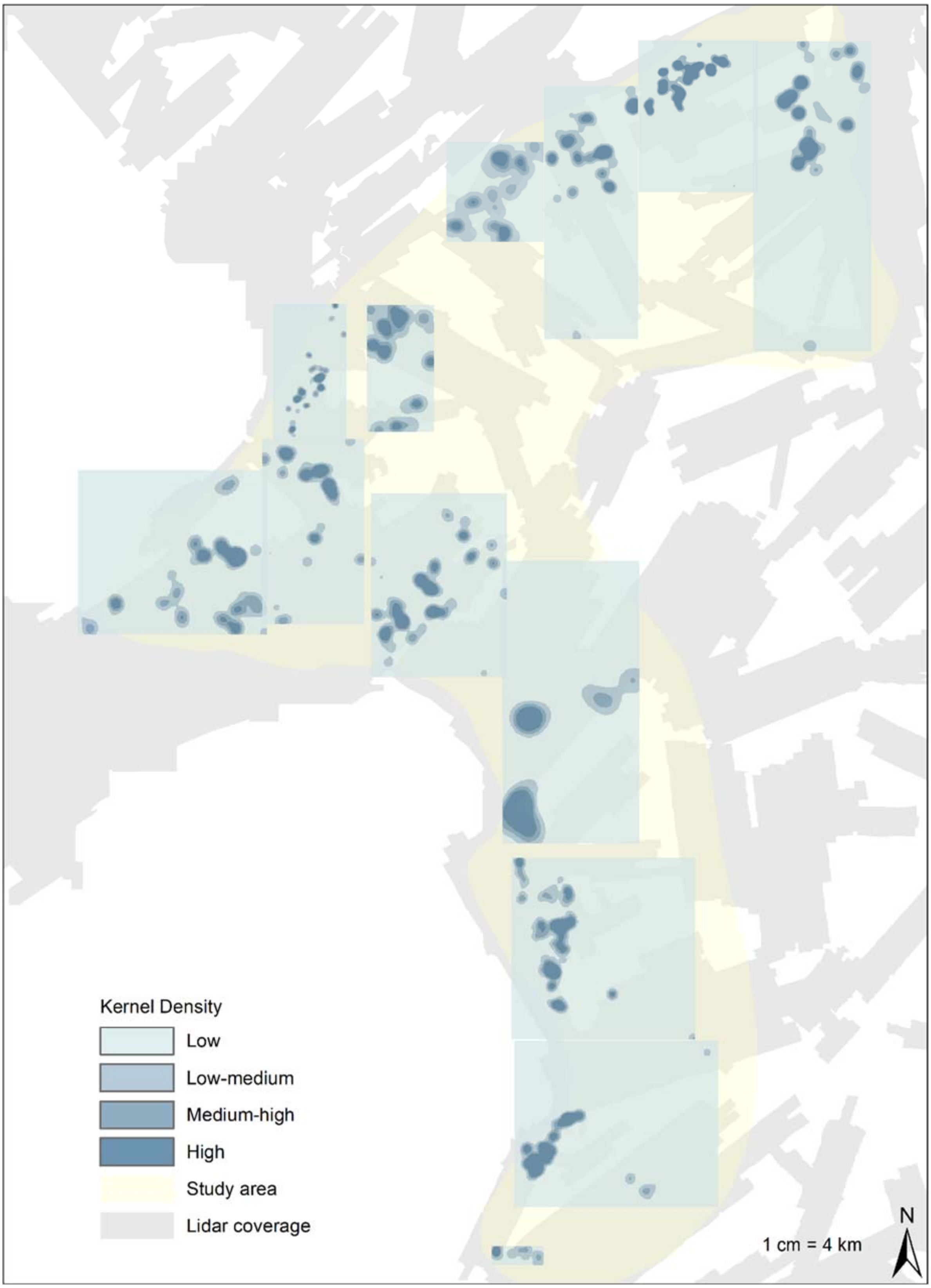


Figure 6.12
Lower tier groupings, shown at 1:350,000

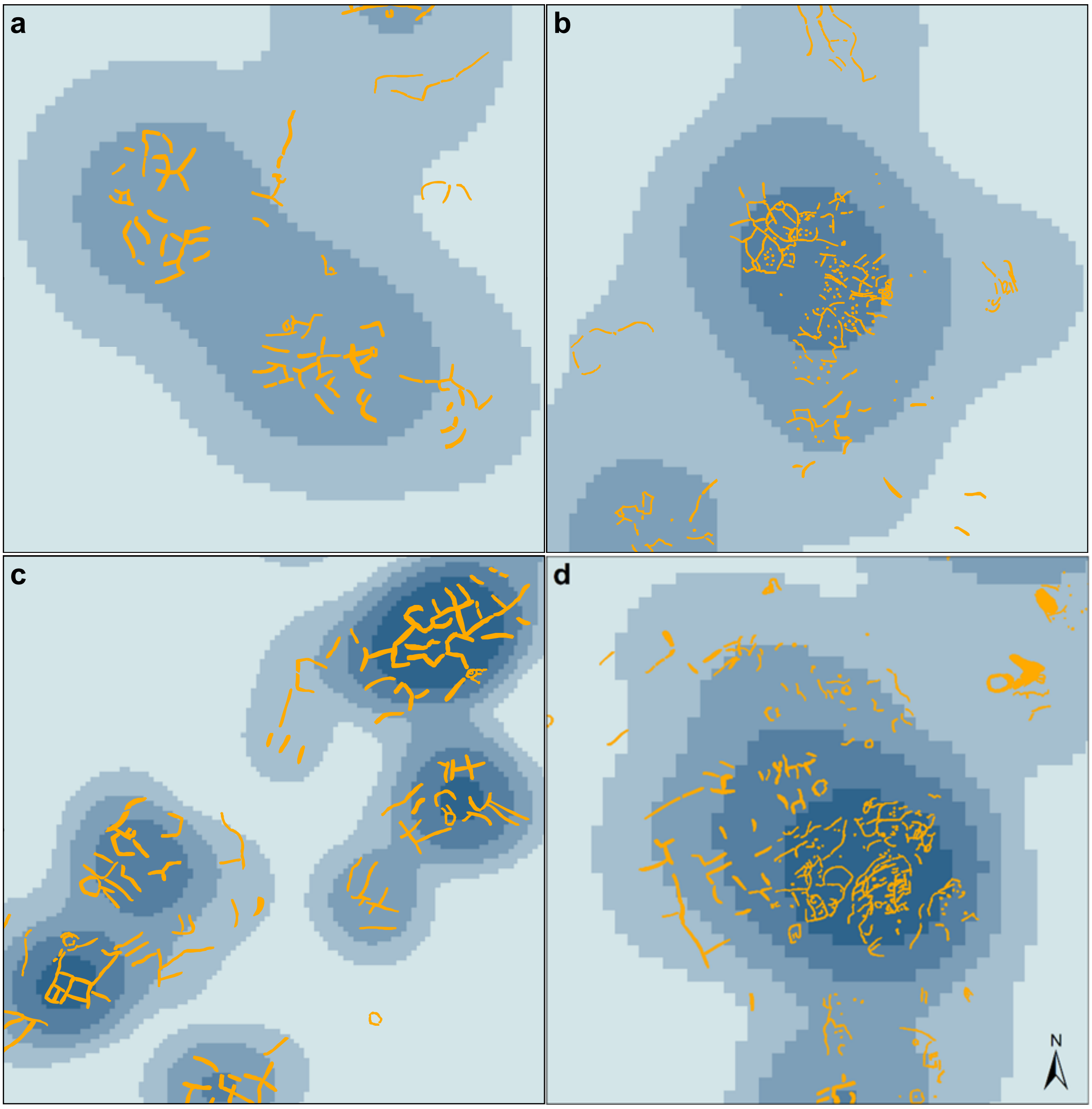


Figure 6.13
Fieldscape polygonal features overlying kernel density plots, all shown at 1:25,000

Sequence shows increasing density and extent of early fieldscape features (a) to (d) overlain on kernel density plots for the mid-slopes at Bryncir, Dolbenmaen (a); upland fields below Pen y Gaer hillfort (b); mid-slopes at Gllynllifon, south of Caernarfon (c); uplands above Egryn Abbey, Tal y Bont (d).

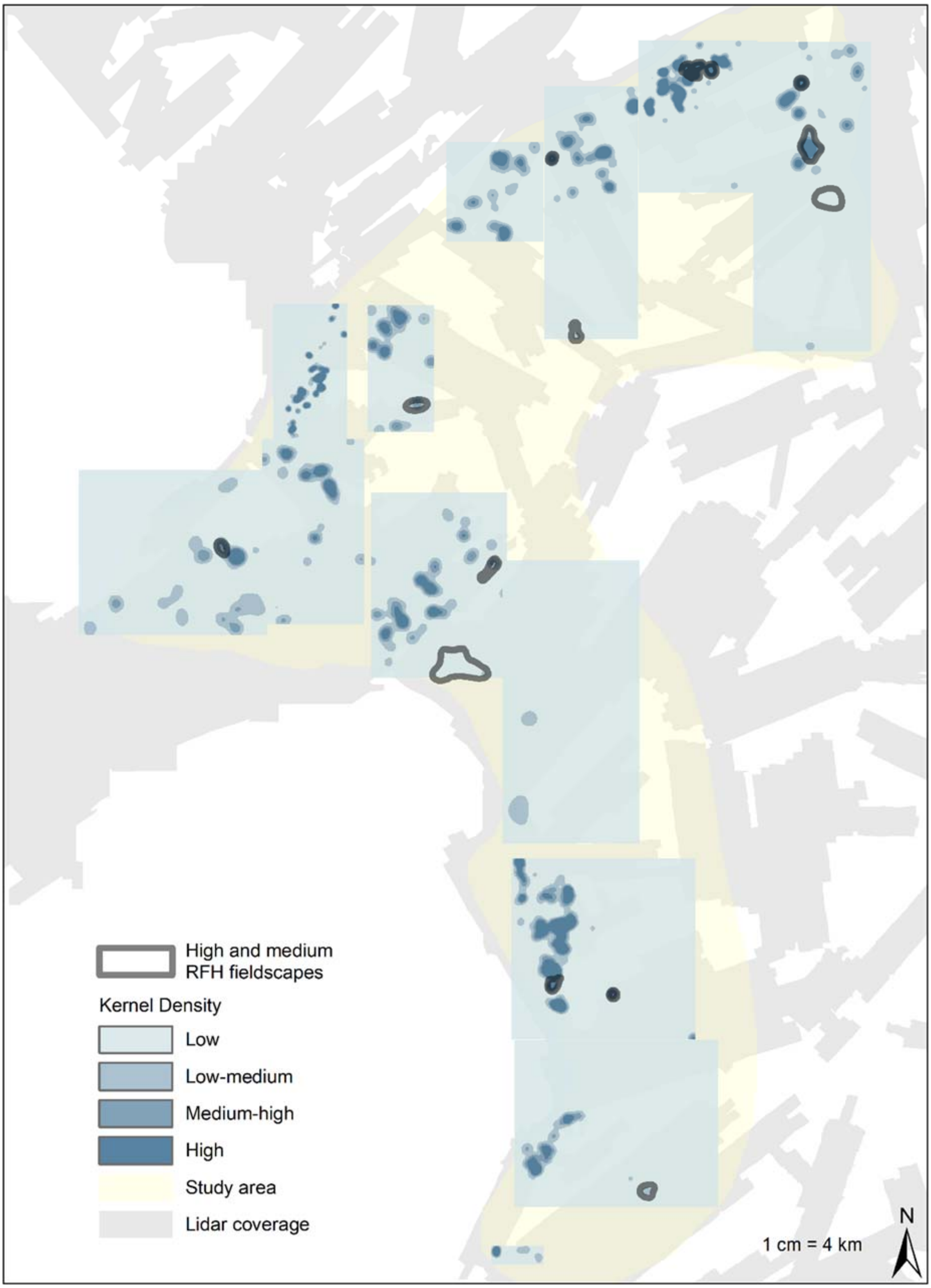


Figure 6.14
High and medium RFH for lower tier groupings, shown at 1:350,000

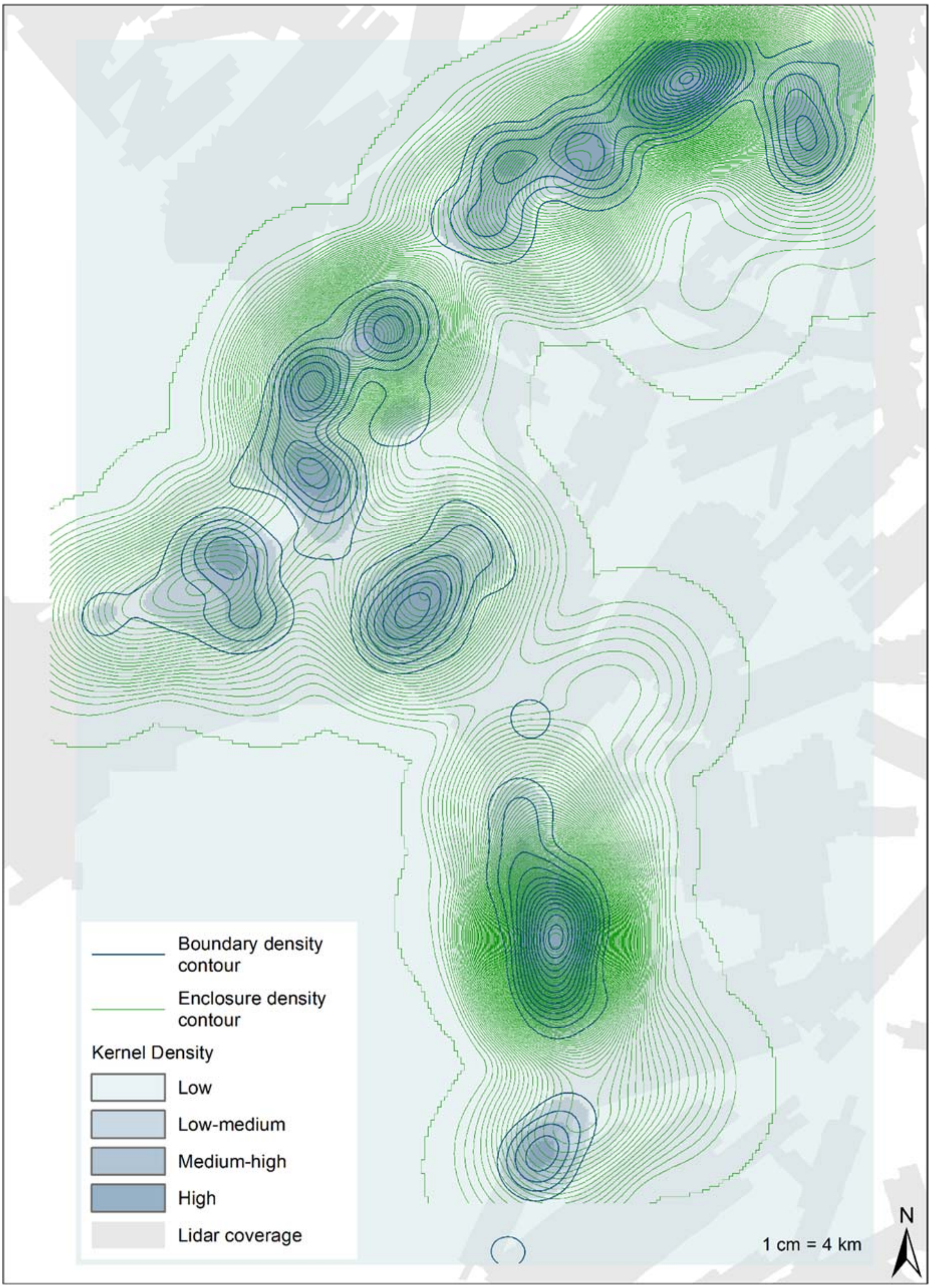


Figure 6.15
Boundary and enclosure groups, shown at 1:350,000

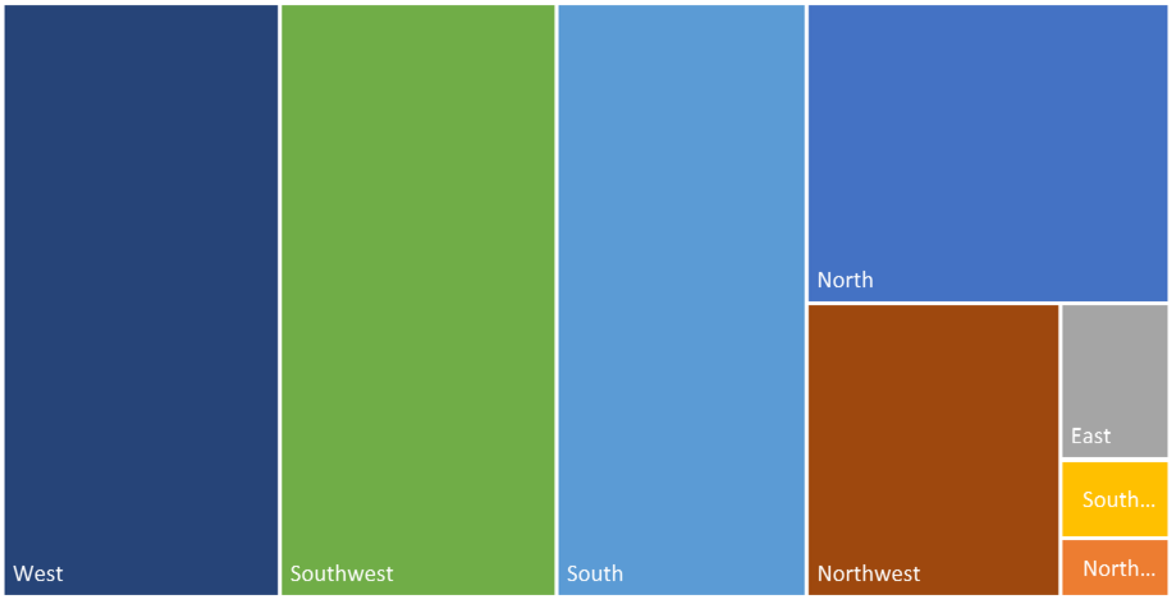


Figure 6.16
Proportion of boundaries situated on the principal facing slopes (aspect)

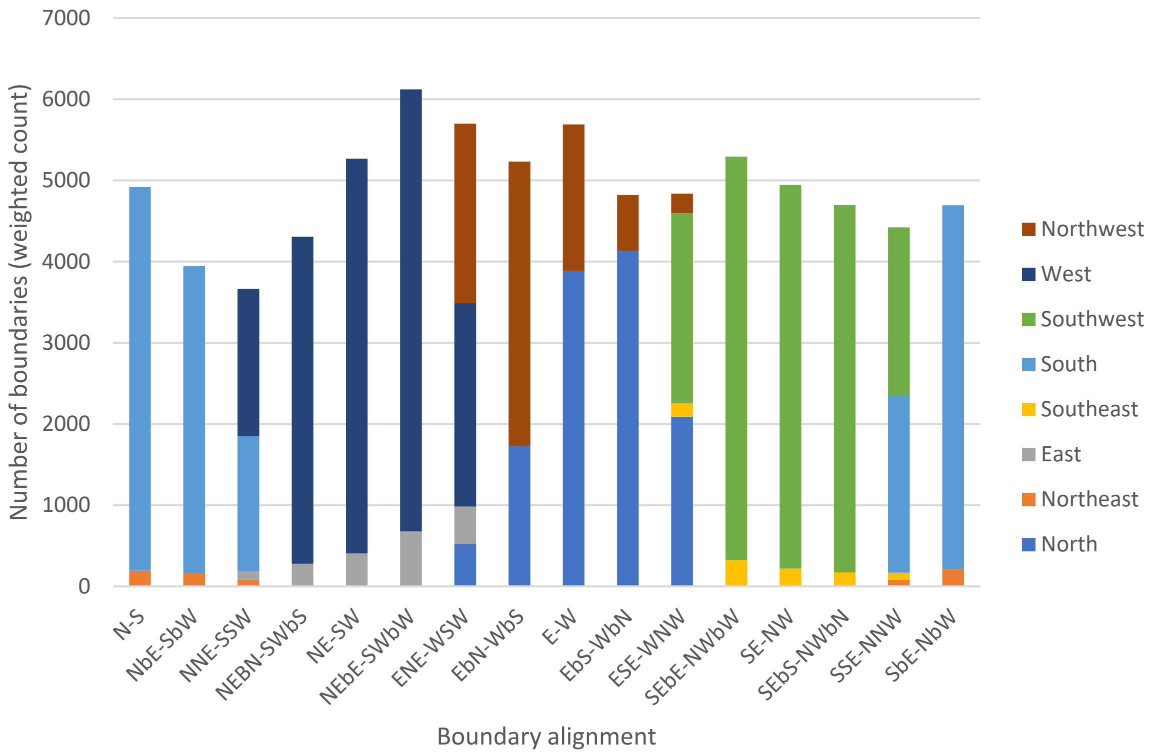


Figure 6.17
Bar chart showing distribution of boundaries by alignment (weighted count) and principal facing slope (aspect)

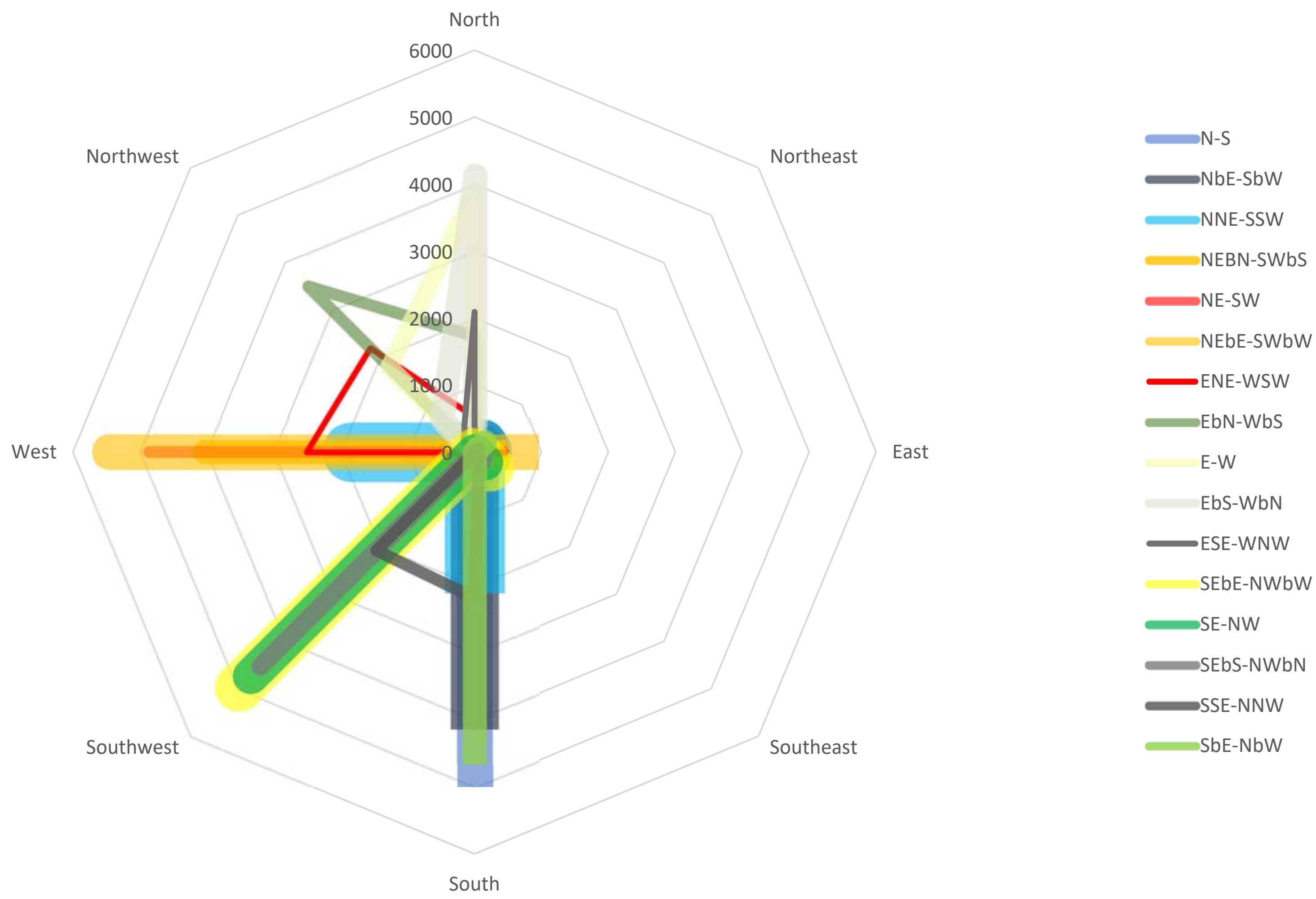


Figure 6.18
Radar plot showing distribution of boundaries by alignment (weighted count) and principal facing slope (aspect)

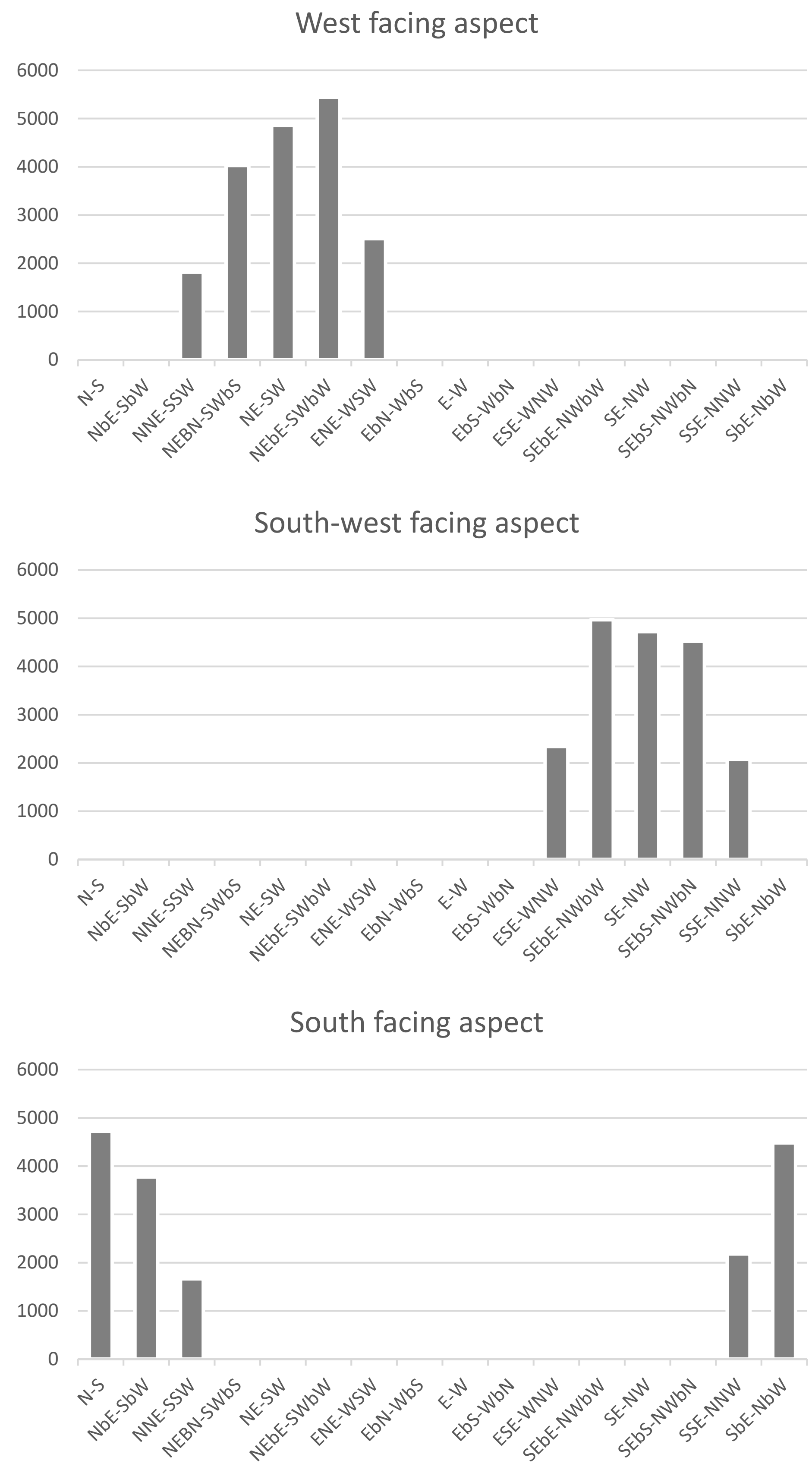
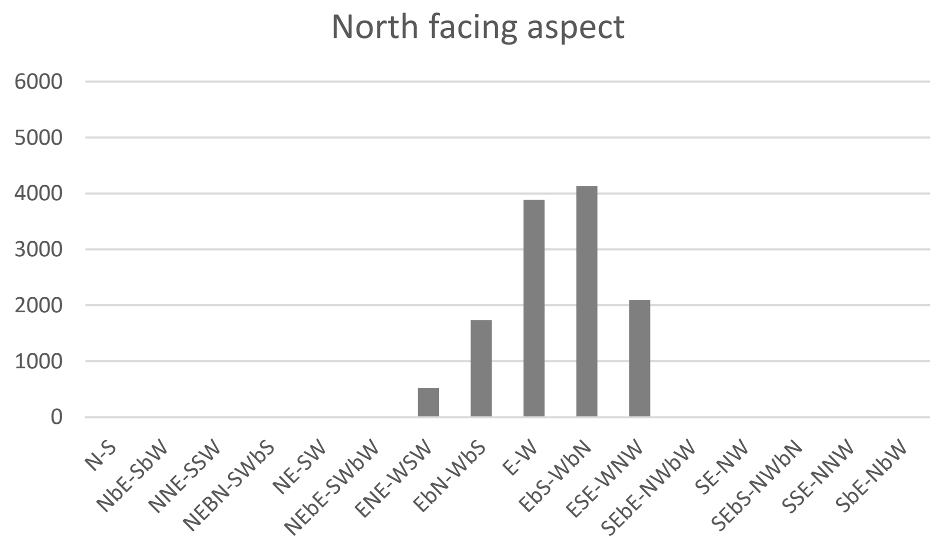


Figure 6.19
Bar chart showing distribution of boundary alignment by principal facing slope (aspect)



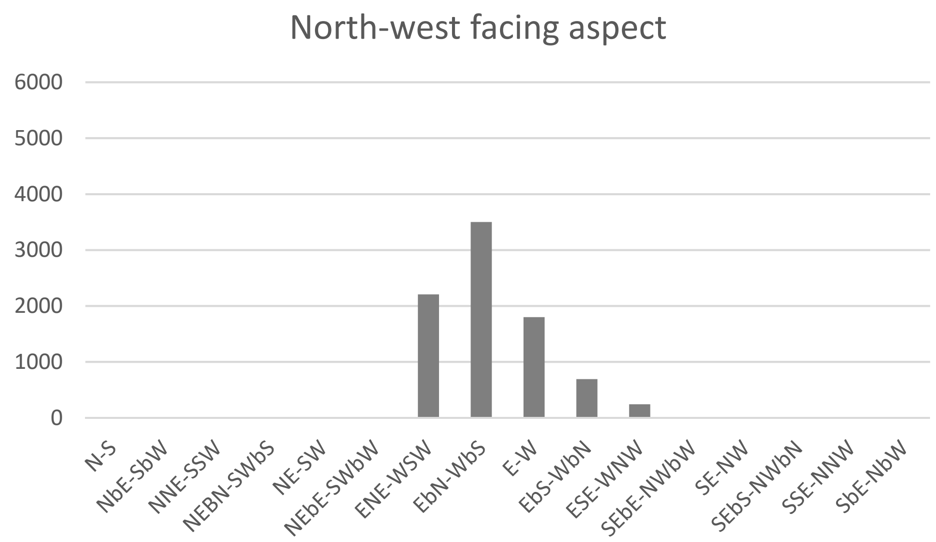


Figure 6.20
Bar chart showing distribution of boundary alignment by principal facing slope (aspect)

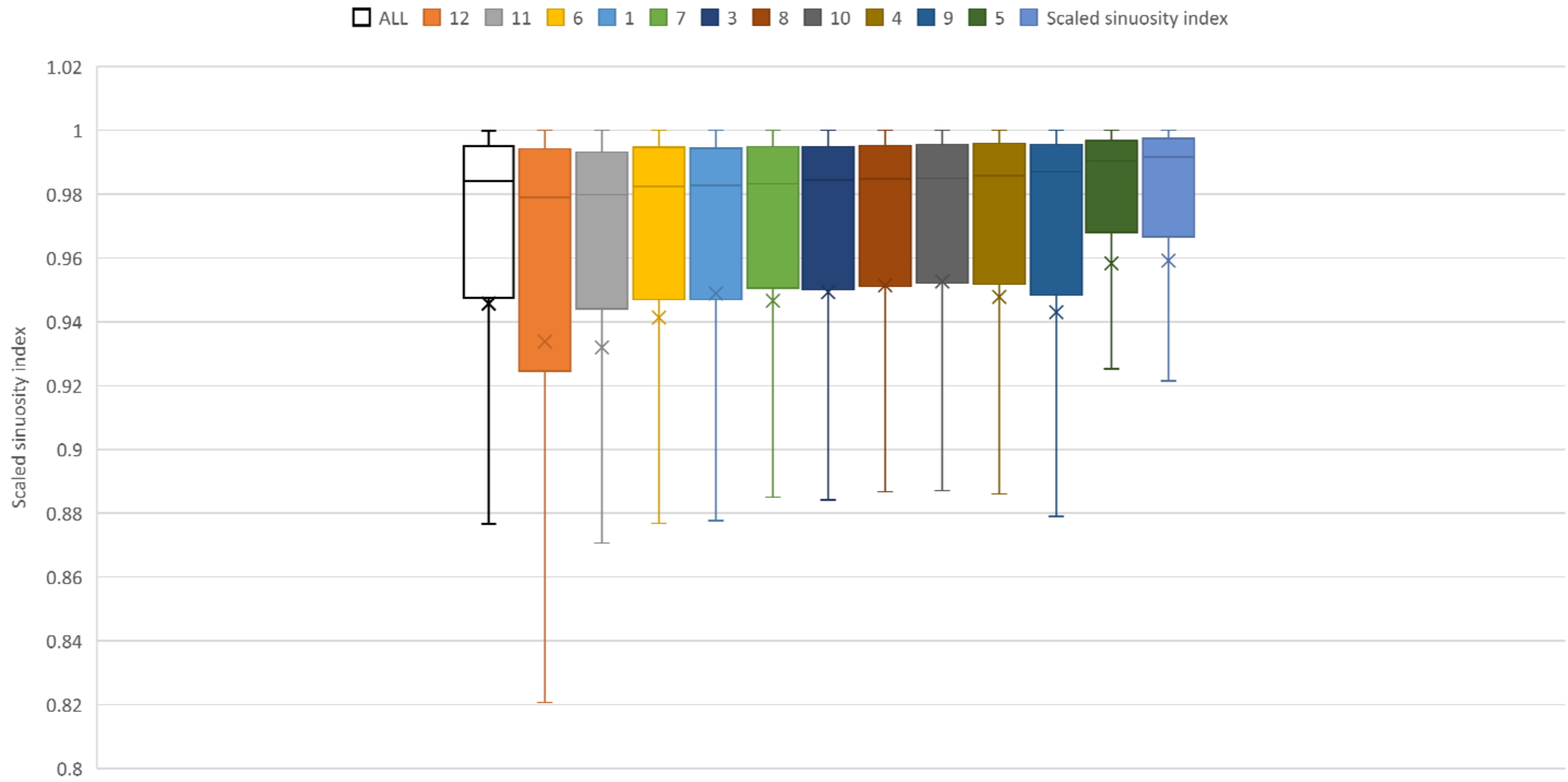


Figure 6.21
Scaled sinuosity index for upper tier groupings (without outliers)

A straight line has an index of 1; location of upper tier groupings shown on Figure 6.23

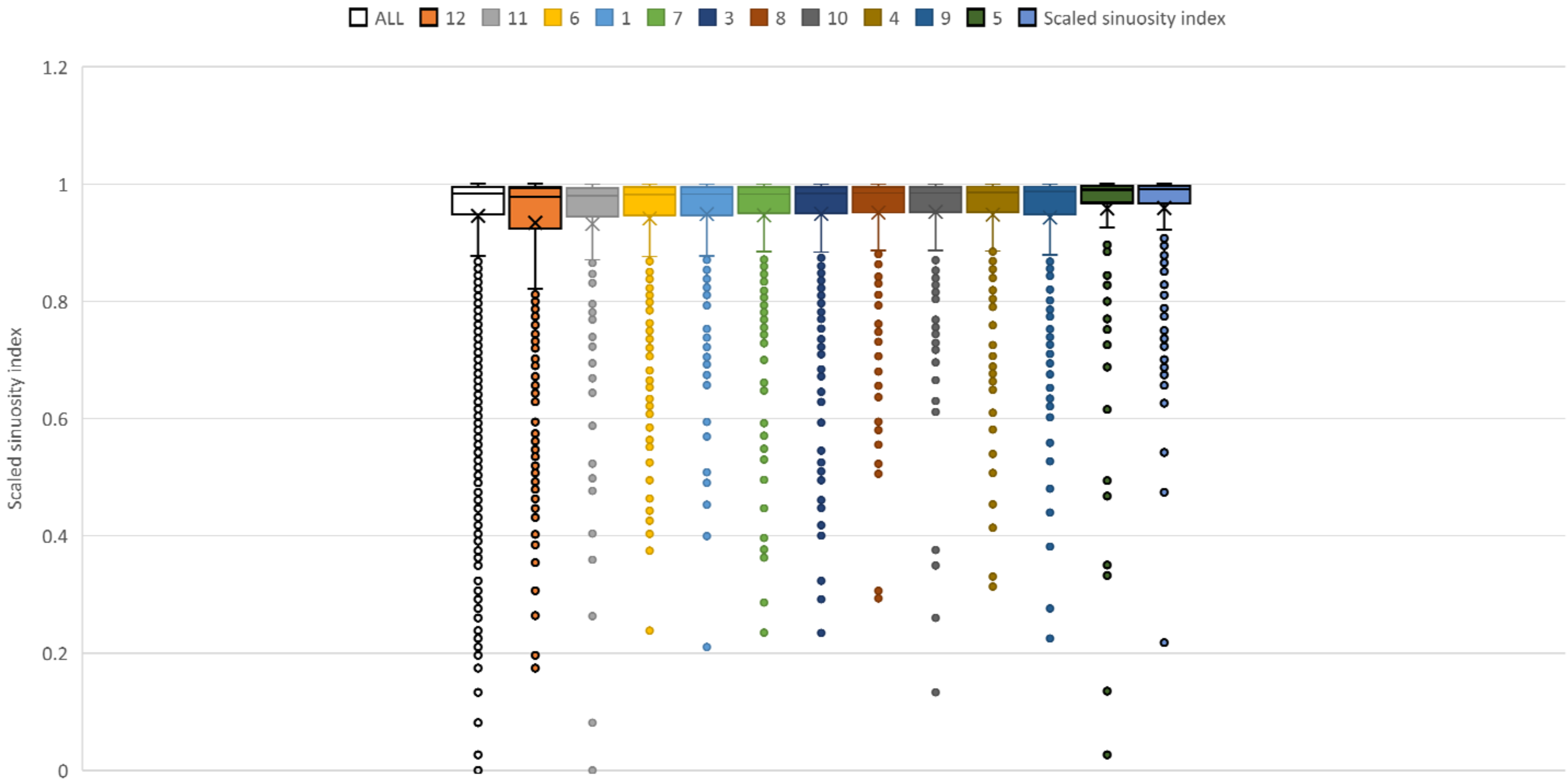


Figure 6.22
Scaled sinuosity index for upper tier groupings (with outliers)

A straight line has an index of 1; location of upper tier groupings shown on Figure 6.23

Figure 6.23
Map showing higher and lower sinuosity upper tier groupings (1-13)

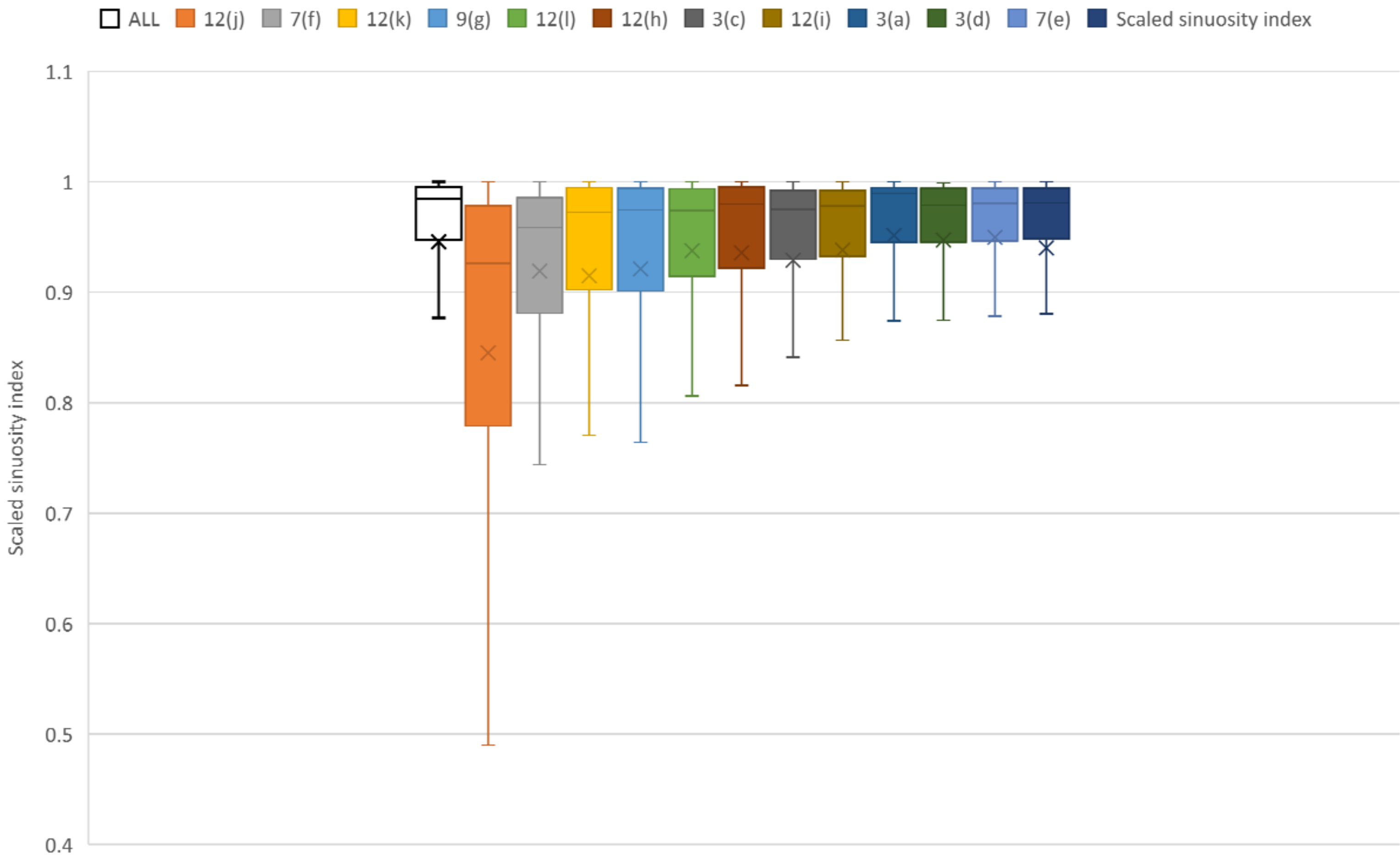


Figure 6.24
Scaled sinuosity index for selected lower tier groupings (without outliers)

A straight line has an index of 1; location of lower tier groupings shown on Figure 6.26

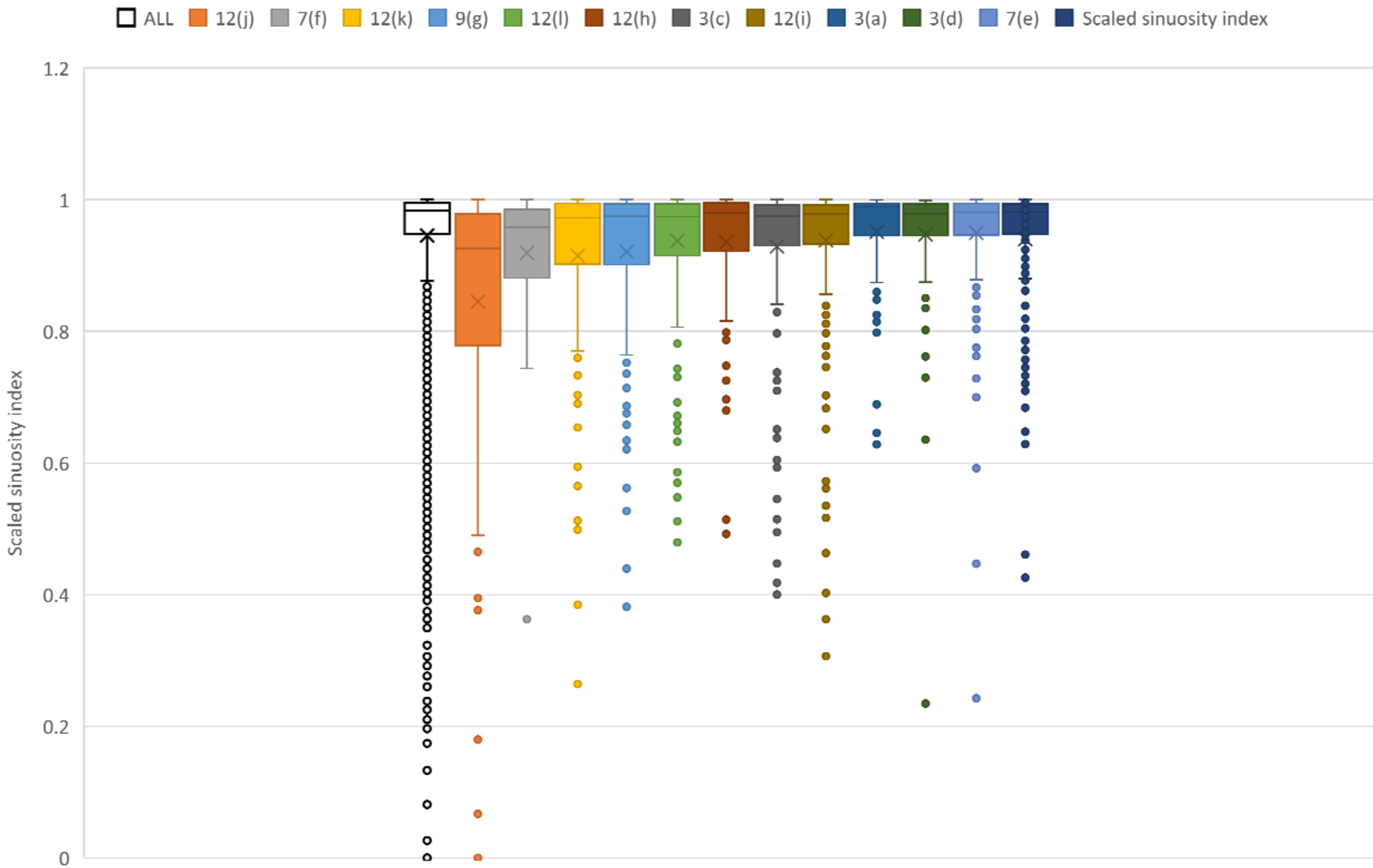


Figure 6.25
Scaled sinuosity index for selected lower tier groupings (with outliers)

A straight line has an index of 1; location of lower tier groupings shown on Figure 6.26

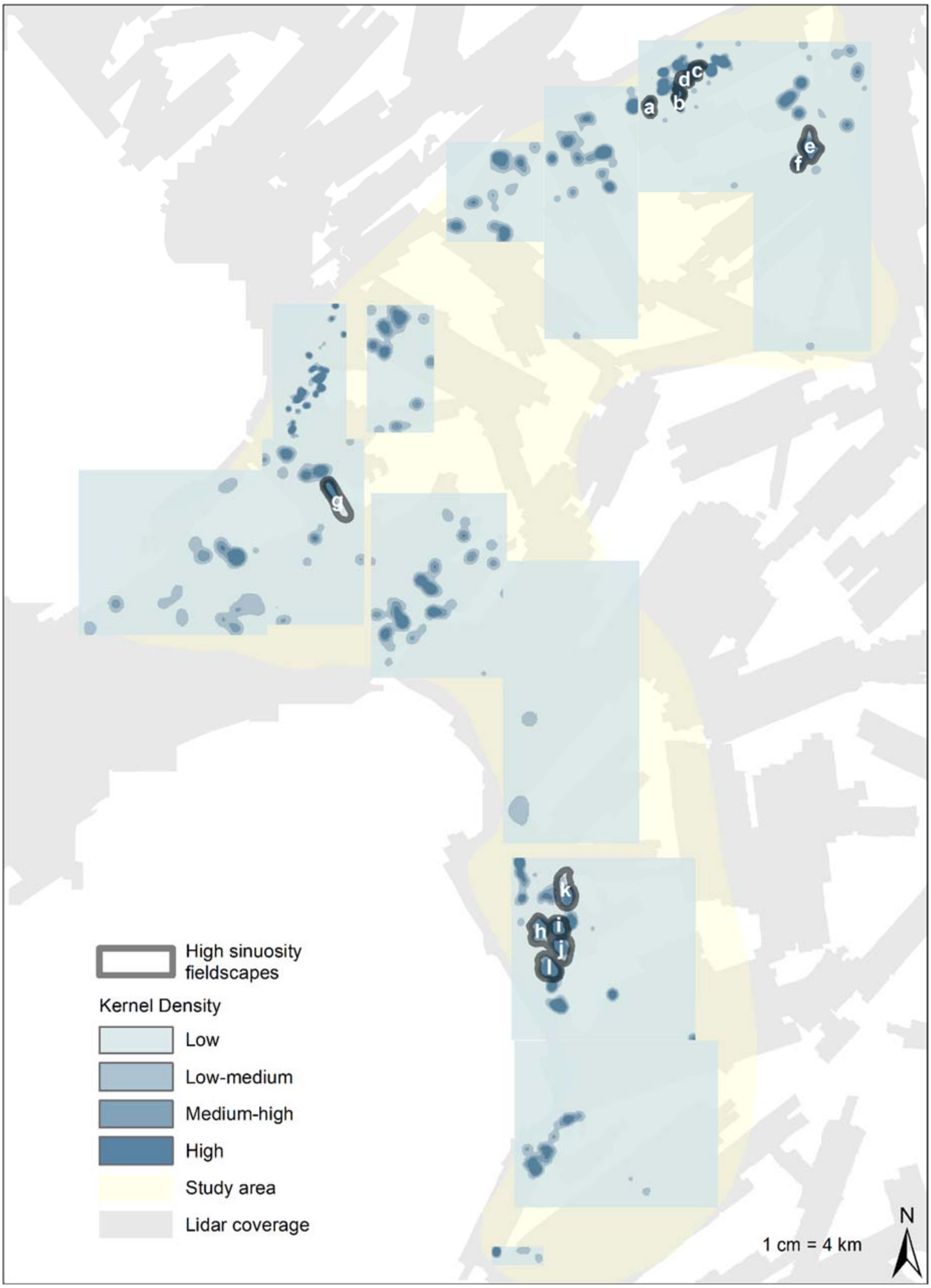
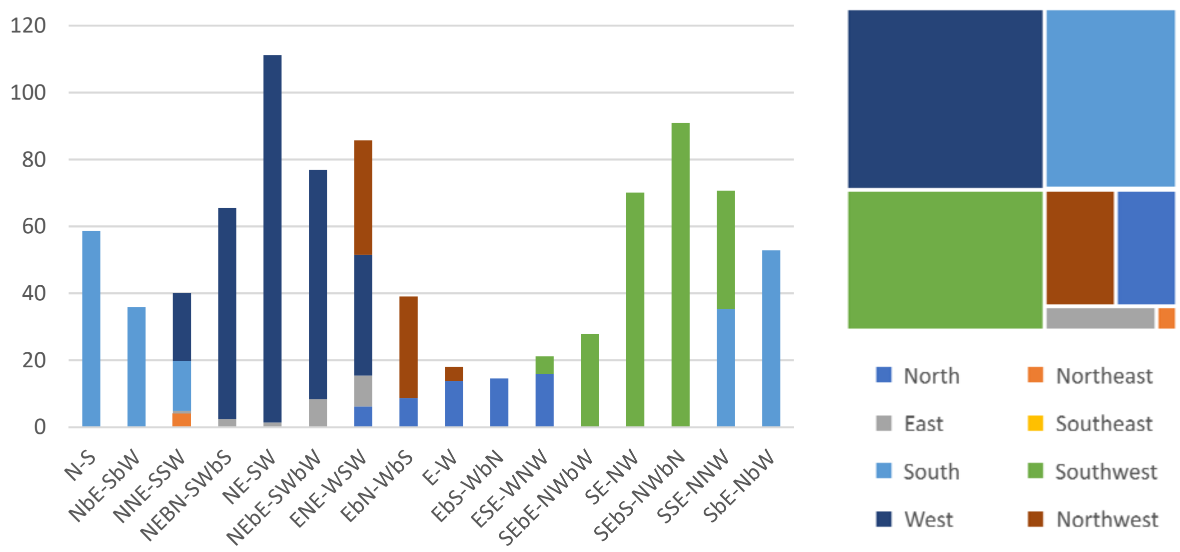
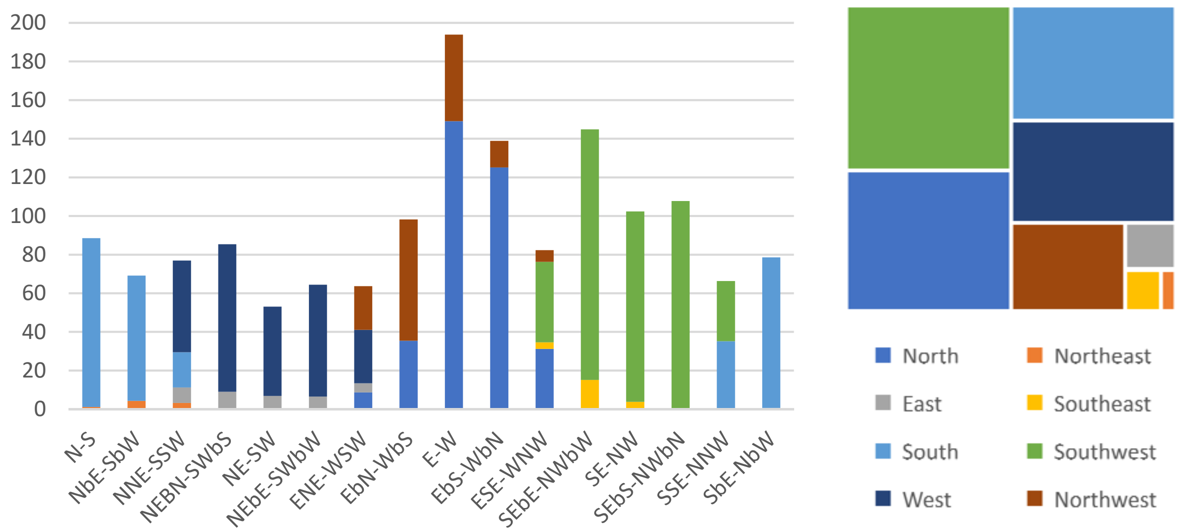


Figure 6.26
Map showing high sinuosity lower tier groupings (a-l)





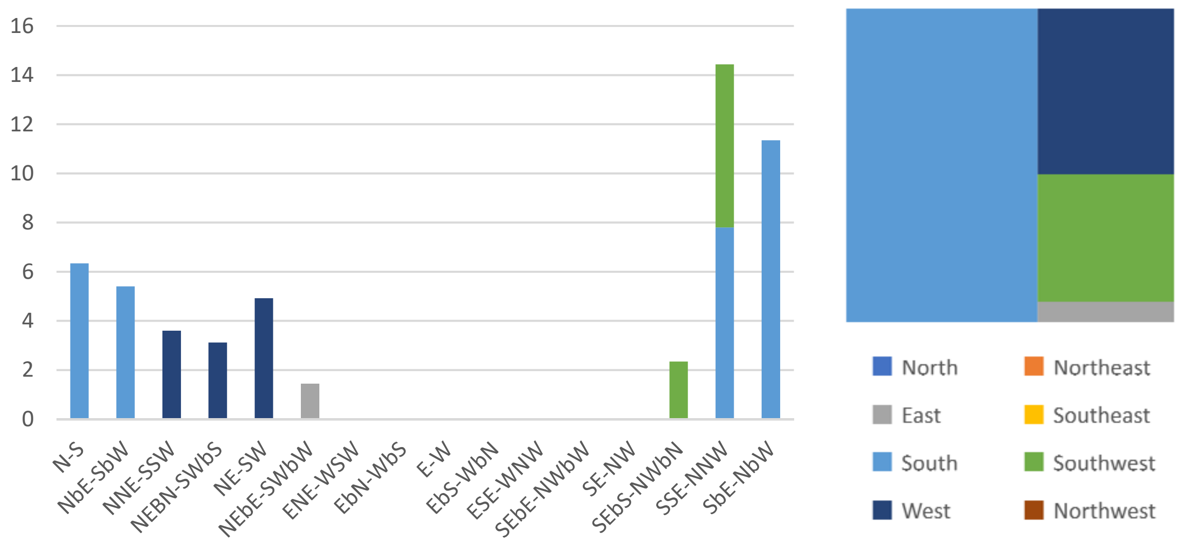


Figure 6.27
Bar chart showing boundary alignment for high sinuosity clusters (a-c) and tree map showing proportion by slope. Distribution of boundaries by their alignment (x axis) and number (y axis).

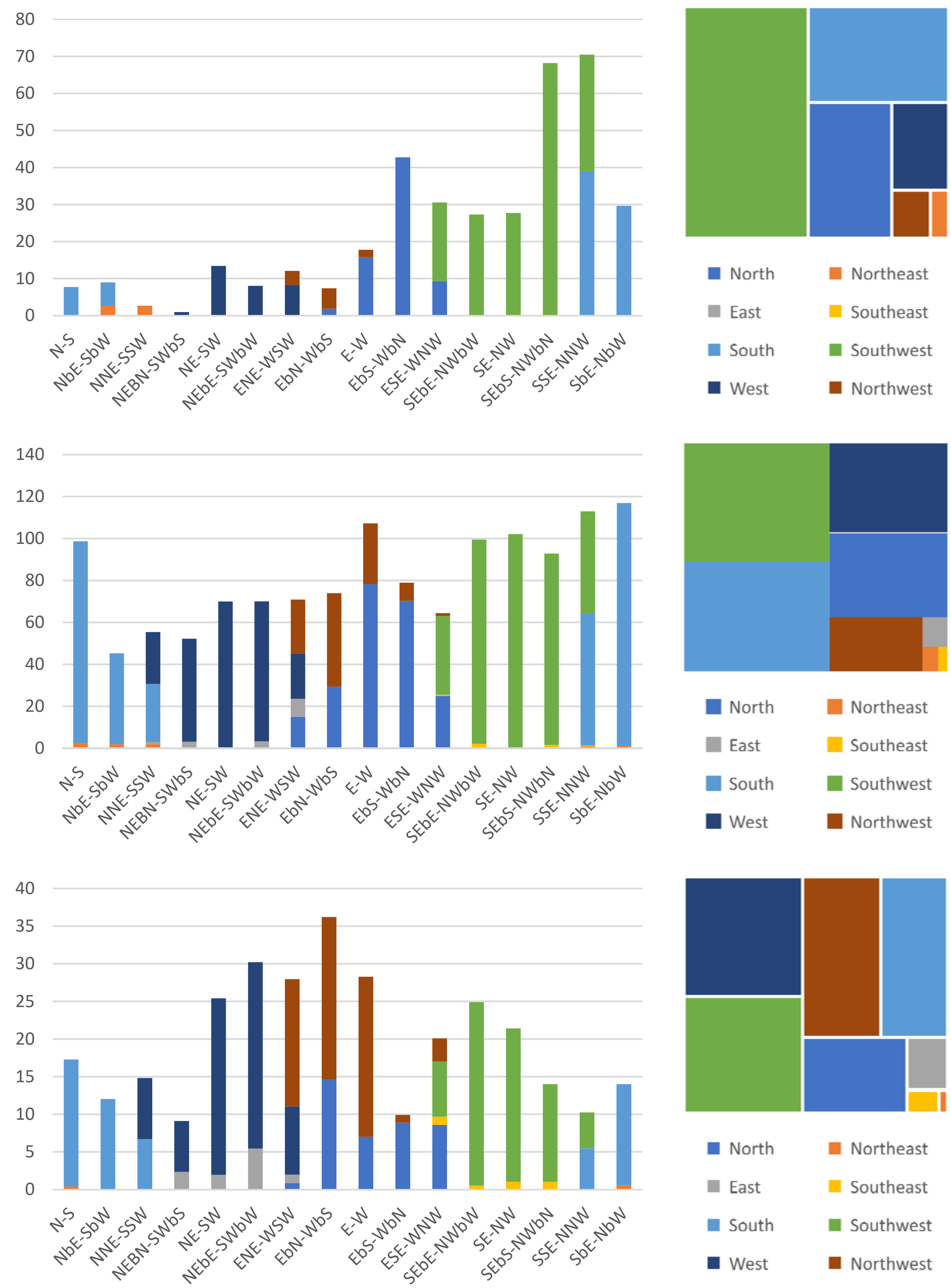


Figure 6.28
Bar chart showing boundary alignment for high sinuosity clusters (d-f) and tree map showing proportion by slope. Distribution of boundaries by their alignment (x axis) and number (y axis).

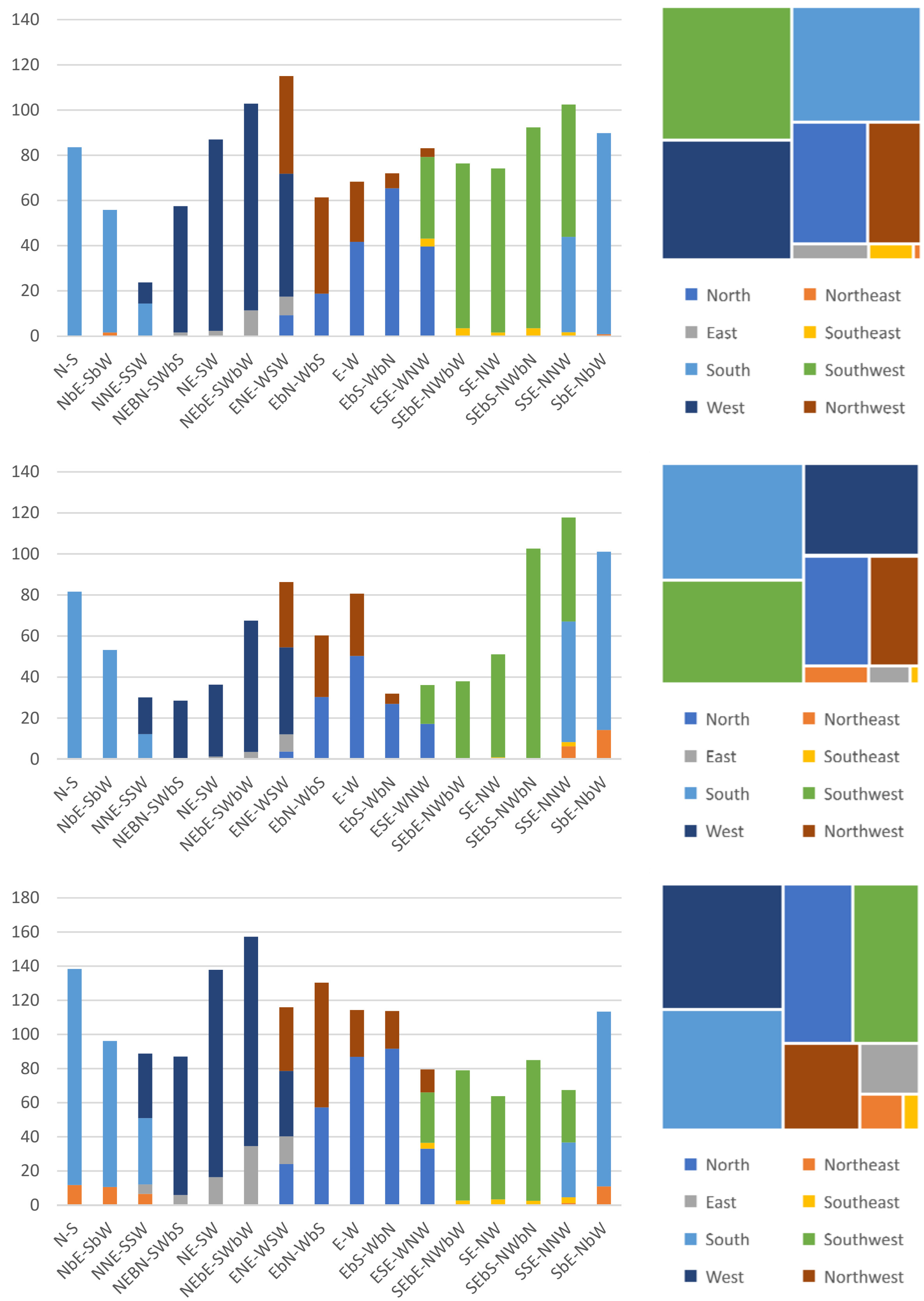


Figure 6.29
Bar chart showing boundary alignment for high sinuosity clusters (g-i) and tree map showing proportion by slope. Distribution of boundaries by their alignment (x axis) and number (y axis).

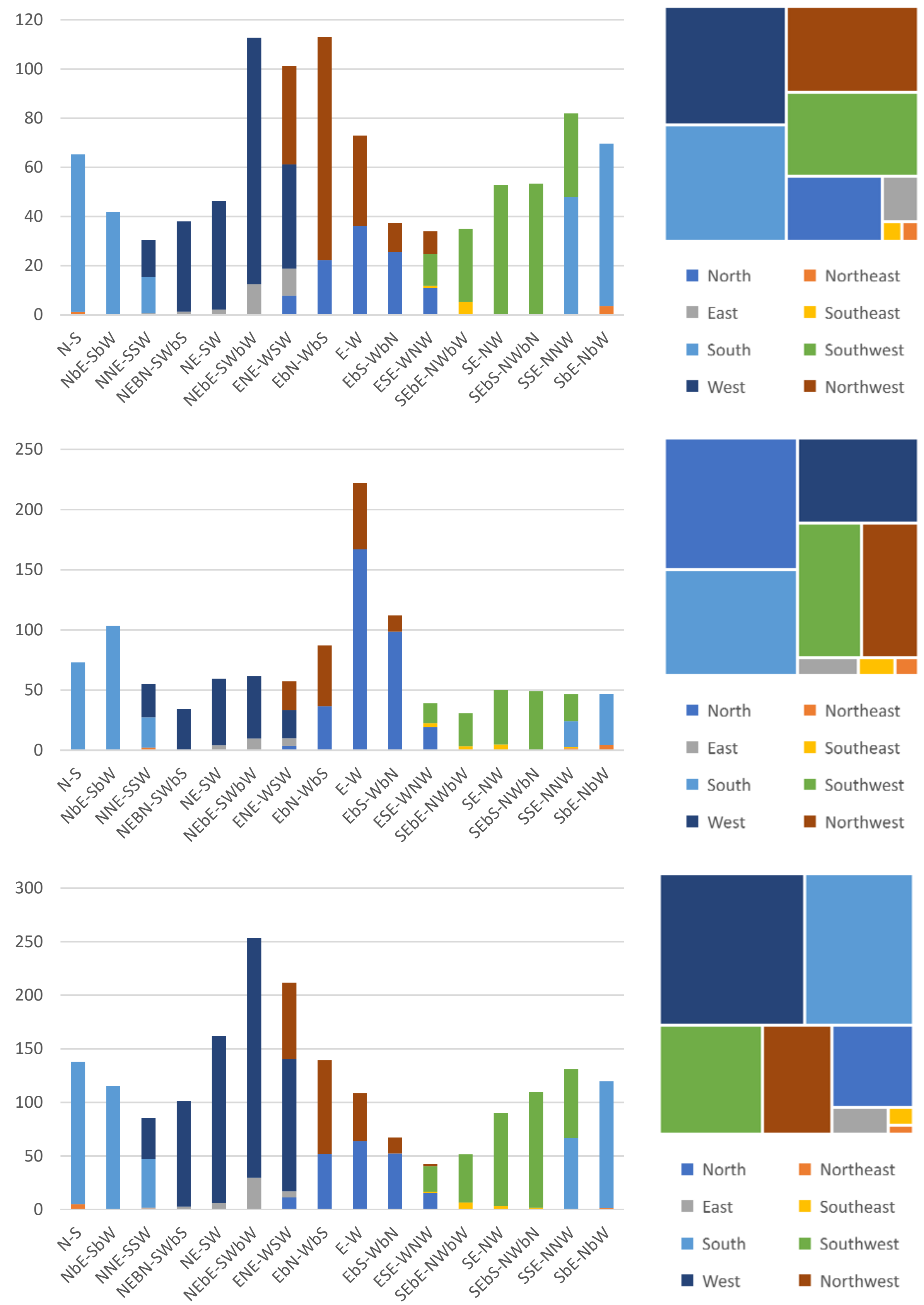


Figure 6.30
Bar chart showing boundary alignment for high sinuosity clusters (j-l) and tree map showing proportion by slope. Distribution of boundaries by their alignment (x axis) and number (y axis).

Chapter 7
Qualitative approaches to early fieldscapes: temporality and materiality

Beyond statistics: qualitative approaches to early fieldscapes

The results presented in chapters 5 and 6 demonstrate how detailed data collection and analysis can help identify new patterns for early land enclosure. This chapter incorporates these findings with qualitative evidence to discuss what they reveal about the human and environmental processes that led to their creation and survival.

Integrating qualitative site-based information is essential to address gaps in the quantitative analysis, specifically the need to include information for areas where there is no lidar coverage or where lidar models do not show known sites. The main sources discussed in this chapter are excavation records and published synthetic studies of roundhouse settlements in northwest Wales. Most of these sites were excavated several decades ago and original interpretations often depend on poorly dated contexts. Re-examining this work has involved recalibrating all original radiocarbon dates using the most recent 2020 calibration curve, OxCal v4.4 (Ramsey 2009), to a 2-sigma range (94.5% probability).

Early fieldscapes and early houses: spatial and chronological patterns

As outlined in chapter 2 and above, understanding the process of enclosure and development of fieldscapes has depended on settlement evidence because houses form the basis for dating other fieldscape elements, either by analogy with excavated sites elsewhere or by spatial association. The detailed study and synthesis of roundhouses in recent years has made the task of incorporating this information a relatively easy one (Ghey 2007, Ghey et al. 2007, Ghey et al. 2008, Waddington 2013). The conclusions by Smith (2008, 2018b) and Waddington (2013) are assessed in greater detail in the main discussion. The broader context is summarised below, taken primarily from Ghey et al. (2007).

- The widespread adoption of roundhouses in Wales can be confidently placed in the Late Bronze Age and Early Iron Age, with relatively few examples of structures dated prior to the late second millennium BC.
- Of the small number of early buildings, principally those dating to the third and earlier second millennium BC, there was a recurring spatial relationship with circular burial and ceremonial monuments.

- Throughout the first millennium BC, timber and stone-built settlements are relatively common, initially as enclosed sites, and later, by the Roman period, as both open and enclosed settlements.
- Building footprints indicate that roundhouses varied in size and layout, with no strong preference for the orientation of entrances.
- Regional patterns appear to be more significant than chronological trends, though there is still considerable variety in roundhouse type in all areas.
- The chronological foundations for discussing roundhouses in Wales are slight, given the large number of sites and low number of radiocarbon dates.
- Some roundhouses were subject to multiple episodes of rebuilding and alteration that cannot be captured by one radiocarbon date; the study illustrates the need for many more radiocarbon dates per settlement.

Of the more than 900 roundhouse records in the early fieldscape study area, only six have radiocarbon dates. There are a further 16 dated sites in the wider northwest Wales region included in Waddington's study, eleven of which are roundhouse settlements. These sites are listed in Table 7.1 and Table 7.2.

The significance of roundhouses for dating the fieldscapes of which they formed a part, is explored in greater detail in relation to the six dated examples within in the study area. Only two of these lie in areas with lidar coverage where it is, therefore, possible to relate them to newly identified (transcribed) features. These two sites are considered first: Crawcwellt West and Graianog East.

Crawcwellt West

Crawcwellt West is located on the gentle south facing slopes of the Rhinogydd, a few kilometres south of Trawsfynydd (transcription map 18). It is the earliest example of a roundhouse in the study area and was identified following a long programme of survey and excavation in the 1980s and 1990s (Crew 1989, Crew 1998).

Its early date is based on a charcoal sample taken from a deep 1m-wide pit that has a calibrated date 755-210 BC[1]. The pit was identified with a sequence of stake-walled roundhouses which were overlaid by later stone-walled roundhouses and iron-smelting furnaces (Crew 1998: 11, 32). Archaeomagnetic determinations[2] gave a *terminus post quem* of 300 BC for the iron-working

[1] 2350±70 uncalibrated BP (SWAN-18)
[2] Archaeomagnetic reference AJC 37

features. Together this evidence suggests a date between the eighth and fourth centuries BC for the pit and, by implication, the roundhouse.

Stretches of irregular field boundaries were recorded over approximately 4 hectares to the south of the settlement, including a short section connecting two of the roundhouses and curved walls incorporating them into a larger oval enclosure (1989: figure 1). Subsequent upland survey work in 2000 (Fairburn 2001) and 2014-15 (Hall and Sambrook 2015) revealed low stone walls, burnt stone mounds, cairns and 'hut platforms' scattered across the open moorland, covering approximately 100 hectares to the north, east and south of the excavated site. In addition to these sites (recorded only as point data fields), are stone banks, ditches, walls and platforms transcribed by the RCAHMW air photo mapping team in 2002 from vertical RAF and oblique aerial photographs.

Taken together these features attest to extensive evidence of activity and settlement from the Bronze Age onwards, but few can be reliably identified on the 1m resolution lidar models. This was an area identified during the transcription process as having poor quality lidar, and it may be that higher resolution or better-quality data collection may reveal more features. In the interim, it is not possible to identify a coherent spatial or chronological link between the Iron Age roundhouses and the wider enclosed landscape.

Graianog East

The second dated example, Graianog East[3], is also situated in an area with a long history of excavation and survey, in this case undertaken in advance of gravel extraction. Quarrying operations are still active with the last mitigation phase carried out in 2015-16.

The first rescue dig took place in 1959 at Cefn Graianog I roundhouse settlement (Hogg 1969), with further major excavations at nearby roundhouse settlements at Cefn Graianog II, carried out between 1977-79, and Graianog East in 1985, 1987 and 1988 (Mason et al. 1998). A fourth site to the west of Cefn Graianog II, referred to here as Cefn Graianog West, was excavated in 1977 and comprised a large medieval farmstead (Kelly 1982b). All but Graianog East have been destroyed. Intermittent assessments and watching briefs have been conducted ahead of quarrying in the intervening years (Flook 1994, Jones 1999, Kenney 2001b, Hopewell and Kenney 2003, Davidson and Roberts 2004, Smith 2004a, Roberts 2007a, Roberts 2008, Rees 2009, Owen 2010, McNicol 2016).

Several programmes of palaeoenvironmental work have been completed for the Graianog Ridge and its immediate environs. The most substantial study was carried out as part of the Cefn Graianog II

[3] The site and area also appear as 'Graeanog' in publications; the farm name as it appears on historic and modern maps is used here.

excavations. It included analysis of a vertical column taken from waterlogged peat deposits close to Graianog West, samples taken from soils buried beneath roundhouses at Cefn Graianog II (Chambers 1998) and comparison with a colluvium section from Graianog West (Kelly 1982b). Soil samples were also analysed from Graianog East (Botterill and Chambers 1998) and Botterill carried out a palaeoecological study of peaty deposits from mires in Cors Cyfelog, less than 2km to the north-east of Graianog (1988). The edited volume summarising the excavations at Cefn Graianog II and Graianog East is heavily reliant on these studies, both for helping to date settlement phases and contextualising broader landscape change (Mason et al. 1998). More recently McKenna assessed the palaeoenvironmental potential of samples from a range of contexts excavated as part of an archaeological evaluation, but no radiocarbon dates have been published from this work so they remain undated (McKenna 2016).

This long and complex sequence of work, focused on the settlement evidence, illustrates the difficulty assessing landscape-scale change when there are so few absolute dates. One radiocarbon date of 410-95 cal. BC[4] was obtained at Graianog East from a charcoal sample taken from an occupation layer and cobbled surface sealed by later stone-built roundhouses (Kelly 1998: 138). Two further dates (165 cal. BC–cal. AD 205[5] and cal. AD 25-380[6]) from a later stone-walled rectangular building have been interpreted by Waddington (2013: 229-230) as indicating a period of occupation from the late second century BC until the fourth century AD. There are no radiocarbon dates for Cefn Graianog II, though a small number accompany the palaeoenvironmental study. The authors of the post-excavation report describe dating the phases as 'exceedingly difficult' (Mason and Fasham 1998: 9)[7].

What emerges from these studies is a broad chronological narrative. By the third century BC the landscape around Graianog was characterised by open pasture and fields, which had eventually replaced closed forest. The earliest evidence for roundhouses and enclosure boundaries dates from between the fifth century to first centuries BC, long after the first woodland clearances. Several phases of abandonment, reconstruction and new building are recorded, lasting into the fourth century AD. During this time, there is evidence for mixed farming, with cultivation of spelt and barley indicating year-round occupation. Some buildings, particularly in the earlier centuries, appear to have been built using wood rather than stone, and towards the last centuries BC and early years AD

[4] 2240±70 uncalibrated BP (CAR-1161), 410-95 cal. BC
[5] 2000±70 uncalibrated BP (CAR-1163), 165 cal. BC – cal. AD 205
[6] 1840±70 uncalibrated BP (CAR-1157), cal. AD 25-380
[7] There are several references in the published monograph to elements from the original excavation and post-excavation work that have not been completed or written up, such as analysis of the macro plant remains by Hillman (Mason and Fasham 1998: 46).

stone-built walls enclosing the houses are a common feature. Only one site, Cefn Graianog II, was eventually re-built and occupied in the early medieval period (radiocarbon dates span the ninth to thirteenth century)[8].

Given the extent of gravel extraction and excavation, it is surprising that so many previously unrecognised boundaries are visible on the lidar models (*Figure 7.1*). Their transcription shows that most survive as very slight features (maximum RFH of 0.04m, and mean RFH of 0.02m), unlike the partially scheduled remains at Caerau, a few hundred metres to the east (maximum RFH of 0.21m, mean RFH of 0.05m). Whilst it is not easy to directly correlate them with buried archaeology, the handful of excavated boundaries highlight their potential significance.

The earliest features identified at Cefn Graianog II were two 'boundaries', interpreted as an agricultural phase dating to about 400-200 BC[9], proceeding the first single roundhouse (1998: figure 5). Their depiction on the site plans is indicative and it is not clear if they are stone boundaries or earthen banks, prompting a discussion in the original report about their precise character. The authors conclude that one boundary was a straight lynchet running roughly north-south, defined as the edge of a cultivated area, and the other a stony bank adjoining it at an angle (1998: 12-14). Both boundaries were overlain by later roundhouses. Pollen analysis of a soil sample taken from a sealed context associated with the lynchet demonstrates the presence of cereals, including spelt wheat, and corn spurrey (a weed of cultivation, often of flax). A separate sample taken from soil below a probable first century AD roundhouse and thought to be from the same lynchet, had a higher proportion of arboreal pollen, with hazel dominating, and high representation of heather (Chambers 1998: 62). Chambers notes that it was likely the heather grew abundantly along the field boundary. The deliberate cultivation and coppicing of hazel to form a hedge is equally plausible, particularly as these samples were distinguished from others by their high percentage of hazel pollen.

A second 'lynchet' was identified in 1978 during a rescue excavation of a scheduled cairn (since destroyed and interpreted at the time as a modern clearance cairn) a few hundred metres to the northwest of Cefn Graianog II. It followed a similar north-south alignment for two further boundaries at right angles to the bank (Mason and Fasham 1998: 96). More extensive boundaries were revealed in 2001 during top soil stripping in the field immediately to the north of Graianog East ahead of quarrying operations (Kenney 2001b), though no samples were taken for further analysis or dating. The boundaries included several stone banks and a narrow ditch. One bank was 3m wide and over

[8] 840±60 uncalibrated BP (CAR-932), cal. AD 1040-1275; 1020±60 uncalibrated BP (CAR-933), cal. AD 890-1160
[9] This 'phase' was based on comparisons between pollen samples, one of which had a calibrated radiocarbon date of 2305±40 BP (CAR-70), 470-205 cal. BC

20m long, buried under 0.4m of colluvium. Kenney suggests that the feature may have formed a broad bank revetting a terrace on the hillslope, with a total length of at least 40m.

Four unexcavated probable early settlements lie within a 1km radius of the sites at Graianog and they show up clearly on the lidar models. There is evidence for early boundaries surviving adjacent or close to three of them[10]; a fourth massively built enclosure and roundhouse[11] to the south of the hillfort at Foel Uchaf may be situated in an area of terraced fields (though they cannot be confidently identified on the 1m lidar models). This is an area with a dense concentration of late prehistoric and Romano-British early fieldscape features. The excavations demonstrate that these remains are very probably just the latest phases of a sequence of occupation and enclosure that unfolded from at least the fifth century BC.

Dated settlements in areas without lidar coverage

The slopes of Moel Goedog, above Harlech, were identified in chapter 5 as a priority for high-resolution lidar survey because of the concentration of known fieldscape features (Bowen and Gresham 1967, Kelly 1982a, Kenney 2013: 221-223) and absence of existing 1m resolution lidar coverage. Three roundhouse settlements with radiocarbon dates are located here, within a few kilometres of each other. Erw Wen and Moel y Gerddi were both excavated in the early 1980s (Kelly 1988b) and Rhiwgoch in 2008-9 (Cooke et al. 2010, Kenney 2012b, Kenney 2013).

Erw Wen and Moel y Gerddi have evidence for at least two phases of occupation: in each case an earlier timber-built roundhouse and a later stone-built structure on a similar footprint. The roundhouse at Erw Wen was enclosed by a circular stone bank and at Moel y Gerddi there is evidence for a timber-palisaded circular enclosure, with a low bank. Although both sites were well-preserved, the dating is reliant on radiocarbon dates obtained from a small number of charcoal samples (Kelly 1988b: 137-139). Four of the seven dates from Moel y Gerddi belong to the fourth and third millennium BC[12], very probably indicating an earlier occupation phase; although Kelly concedes that three prove the existence of Neolithic material on the site, the fourth is characterised as redeposited timber[13]. The three first millennium dates are attributed to the timber-built roundhouse[14] and palisade[15]. The dates from Erw Wen are restricted to the first millennium BC and

[10] PRN 3999, PRN 118, PRN 121
[11] PRN 193
[12] 4590 ± 80 uncalibrated BP (CAR-397), 3630-3030 cal. BC; 4590 ± 80 uncalibrated BP (CAR-527), 3630-3030 cal. BC; 4030 ± 80 uncalibrated BP (CAR-528), 2870-2345 cal. BC; and 4760 ± 70 uncalibrated BP (CAR-525), 3655-3370 cal. BC.
[13] 4760 ± 70 uncalibrated BP (CAR-525), 3655-3370 cal. BC.
[14] 2350 ± 70 uncalibrated BP (CAR-398), 755-210 cal. BC; 2290 ± 70 BP (CAR-529), 730-170 BC.
[15] 2250 ± 110 uncalibrated BP (CAR-526), 750-5 cal. BC.

provide only a broad span for the timber[16] and stone-built roundhouses[17], and stone enclosure wall[18]. Thus, the evidence from Erw Wen and Moel y Gerddi point to several settlement phases between the fourth to first millennium BC, possibly synchronous with one another during the middle of the first millennium.

By contrast, the large stone roundhouse at Rhiwgoch has remarkably good evidence for its construction and use, despite modern disturbance and poor preservation. Improved dating standards, including careful sampling strategies, duplicate samples, and the application of Bayesian modelling, meant that it was possible to demonstrate both its construction date, shortly before Roman colonisation, and continued use, through to the later second century AD (Kenney 2013: 219). This is the only example of advanced dating approaches for a roundhouse in Snowdonia.

One of the two other sites with radiocarbon dates has parallels with Rhiwgoch: Cyfannedd Fawr is a large stone roundhouse (about 10m diameter) with evidence for internal drainage gullies and a central hearth (Crew 1978, Crew 1979). Several hearth contexts were identified, interpreted by Crew as different occupation phases from the Middle to Late Iron Age to early Romano-British period. The other is from a single roundhouse on the slopes of Mynydd Egryn, Hengwm, excavated as part of the Ardudwy early landscapes project[19] carried out between 2002-2005 (Johnston and Roberts 2001, Johnston and Roberts 2002, Johnston and Roberts 2003a, Johnston and Roberts 2004, Johnston and Roberts 2005). The roundhouse was situated amongst a dispersed pattern of buildings and enclosures and overlay evidence of an earlier settlement phase, dating to the fourth to first centuries BC [20] (Waddington 2013: 259).

Dating and temporality

The detailed review of radiocarbon dated settlements in the study area has important implications for understanding roundhouses and by implication the boundaries and enclosures associated with them. Because it is not possible to compare when and for how long settlements were occupied, abandoned and re-used, any spatial patterning or chronological phasing needs to be considered carefully. The evidence, as it currently stands, does not support drawing direct or causal links between, for example, changing settlement permanence and nucleation, or between agricultural intensification and settlement nucleation. Rather than struggling to fit the evidence into established

[16] 2470 ± 70 uncalibrated BP (CAR-532), 775-410 cal. BC.
[17] 2260 ± 60 uncalibrated BP (CAR-531), 415-165 cal. BC.
[18] 2410 ± 60 uncalibrated BP (CAR-530), 755-395 cal. BC.
[19] https://www.bangor.ac.uk/history-philosophy-and-social-sciences/research/history/archaeology/ardudwy/index.php.en
[20] 370-90 cal. BC (laboratory Wk19535)

narratives, the analysis presented here focuses instead on how it can shape new approaches and guide priorities for future research.

Of the 39 excavated roundhouse sites within the study area, the clearest trend observed by Smith (1999b), (2018b), Ghey et al. (2008) and (Waddington 2013) is a tendency for clay-walled, timber-post or stake-walled roundhouses to be replaced by stone-walled roundhouses, as described above for Erw Wen and Moel y Gerddi. Kelly argues that that this may have been because timber became increasingly scarce and was therefore replaced with stone (1988b). Smith offers an alternative explanation, suggesting that it was a possible development in construction to prolong the life of buildings by avoiding setting timbers directly into the earth (2018b). These are plausible explanations, given long-term decreases in woodland cover observed from palaeoenvironmental studies and the intrinsic properties of stone. They are also explanations that draw on normative concepts of rationality and universality: the longevity per se of a building is regarded as a desired outcome, rather than the product of a specific cultural context; scarcity is understood as something governed solely by natural abundance (or lack of it) and proximity (physical access), rather than being influenced by economic structures and political control.

Although there is no convincing evidence for occupation length from excavated roundhouses in Snowdonia, evidence from southern Britain and parts of Europe suggest relatively short-term neolocal residence patterns (Brück 1999, Roymans and Theuws 1999). As Wickstead notes in her analysis of later prehistoric Dartmoor, the lifecycles of buildings often lasted only a single generation (2007). If the use of stone increased significantly in the first century AD, the wider cultural and political context of invasion and colonisation by the Romans is relevant for understanding this change: perhaps timber previously used to build houses was deployed elsewhere, either to resist conquest or as a resource controlled and exploited by new Roman colonial masters. These changes may have been initiated by and/or consolidated wider social and political shifts towards longer-lived settlement patterns.

The durability of stone underpins another set of associations recognised for roundhouse settlements. Like transcription from lidar models, field survey has been biased towards stone-built (and earth or clay-walled) roundhouses. Based primarily on survey work carried out between 1994-1998 (Smith 1999a, Smith 1999c, Smith 2001, Smith 1999b), Smith identified strong associations between altitude, settlement site density and nucleation (Smith 2018b: figure 15). He also calculated the average internal and external diameter of roundhouses and found a consistent decrease in size with altitude. Below 100m elevation the average internal diameter was 6.7m, above 500m it was 4.1m. The total number of houses was greatest between 100 and 300m, with slightly lower numbers recorded below 100m and between 300 and 400m elevation. Above 400m, the decrease in the number of settlements was more marked. He also noted a distinctive trend for settlement nucleation, which decreased above 300m, being rare above 400m.

Direct comparison between these settlement patterns and the early fieldscapes dataset is not possible because of differences between the two study areas: Smith's analysis included additional low-lying land on Anglesey and the westerly tip of the Llŷn Peninsula. Despite this, lower settlement density and nucleation above 300m elevation are observations that appear hold for the early fieldscapes dataset: the main monument types identified above 400m are cairns and (relatively) small numbers of prehistoric monuments. The other associations are more difficult to evaluate. The disparity between recorded roundhouse sites and their transcription from the lidar models - as noted in chapter 6, only 15% of known sites were digitised – means that house size and number cannot be accurately assessed (figure 5.40). The early fieldscape digitisation does, however, shed light on these patterns and their significance.

The extensive distribution of features recognised through analysis of lidar models suggests that the relative density of settlement below about 300m elevation is strongly affected by preservation levels. The identification of ploughed out banks in lower-lying areas and variations in RFH, as outlined in chapter 6, point to patterns of enclosure that continue from the mid-slopes. Nucleated and enclosed settlements mainly survive in small, uncultivated areas of woodland and scrub, for example at Corion Rough[21], Tregarth, and Wern Newyd[22], Llanfairfechan, where they have escaped damage from more intensive land-use. This is likely to explain the lower number of houses below 100m elevation and may also help explain why those that have been identified tend to be more substantial examples (that is, with a larger diameter) which would have taken greater effort to remove.

At higher altitudes, where stone-built roundhouses survive in larger numbers but become less nucleated, poorer preservation of more ephemeral structures distorts our understanding of settlement patterns and alters, albeit subtly, perceptions of the viability of living in the uplands. Stone-built roundhouses are known to have been enclosed by boundaries made of wood, for example at Moel y Gerddi, and the converse is true, with clay or timber-built roundhouses associated with stone boundaries, such as the example at Graianog. Traces of timber-walled houses can survive as flattened, circular platforms or hollows, as noted by Smith within hillforts at Caer Seion (Conwy), Pen-y-Gaer (Conwy), Pen-y-Gaer (Llŷn) and Caer Euni (Bala) (2018b). Many more

[21] PRN 27, Scheduled Monument CN268
[22] PRN 257, Scheduled Monument CN250

examples are likely to survive outside these contexts but recognising them is difficult, particularly in areas where they are not expected or sought. As Smith notes, of the 1725 recorded examples of roundhouses in northwest Wales (excluding those within defended enclosures or hillforts), there are 203 surviving only as platforms but none of these have yet been investigated by excavation (Smith 1999b). 'House platforms' have conventionally been associated with medieval settlement. An exception is the targeted investigation of field systems, which revealed evidence for flattened, circular 'hollows', interpreted as the site of roundhouses, identified through geophysical survey at Cwm Cilio, Llanaelhaearn (Smith et al. 2018).

At 1m resolution, most circular 'platform' features were not obvious on lidar models. Comparison with the walkover survey results at Cwm Cilio shows that a group of possible roundhouses can be correlated with poorly defined circular features along a nineteenth-century boundary (Smith et al. 2018: figure 4). Higher resolution lidar data has the potential to reveal similar examples.

By contrast, stone-built enclosures showed up clearly on the 1m lidar models and many more were identified and included in the early fieldscape dataset. More than half (53%) do not have evidence for roundhouses or other early settlement remains, but the grouping analysis outlined in chapter 6 demonstrates that their distribution is similar to the main (upper tier) groups for boundaries, implying a link between the two. There does not, however, appear to be an association between roundhouse records for enclosures and feature survival: groups with greater RFH do not have a higher proportion of roundhouses. This pattern can be interpreted in several ways. The enclosures may not relate to settlement but could instead have been used to corral stock or protect plots of cultivated land, as suggested by others (e.g. Waddington 2013: 70). They could also be the traces of boundaries that once enclosed timber not stone-built roundhouses.

Early fieldscapes and early boundaries: materiality

Like other fieldscape elements, boundaries were recorded as part of this PhD research through the description of both their character (type) and monumentality (monument). Despite the similarity between the transcription and research categorisation datasets, the division serves as a reminder of both qualities and the relationship between them. What appears at first to be self-evident, almost banal - that a boundary is made up of cobbled stone or that it extends for a few hundred metres - belies its material and conceptual significance. These ideas are explored in greater detail this section.

As cautioned in the descriptive analysis presented in chapter 5, the recorded physical form of a boundary only partially reveals the processes that resulted in its creation, use, re-use and potential abandonment: its individual biography. The 'banks' and 'flattened wide banks' represent collapsed, grassed over and, to varying degrees, ploughed out walls that were constructed from stone or earth, or combinations of the two.

The underrepresentation of negative boundary features such as ditches also means that construction techniques which involved digging a ditch and depositing material to create a bank are rarely recognised. This is potentially significant because the stock proofing qualities of low banks are enhanced by the addition of a ditch, particularly for cattle (Fry 2009: 226). The use of the term 'lynchet' to describe a stepped boundary edge also reduces a range of different processes to one form. It has usually been recorded as the product of ploughing a terraced strip of land (Smith et al. 2018: 3), however, the accumulation of soil against a boundary which is subsequently removed, the loss of upstanding walls and banks, and the tendency of different slopes and soils to form 'steps' can result in similar landforms. The physical remains therefore attest to varying levels and types of labour, continued use and re-use.

Field survey work in the case study areas demonstrated several different early boundary traditions. Some walls were deliberately built with flat-sided stones 'facing' at least one boundary edge (*Figure 7.2*), but the use of irregularly shaped stone is more common. Sometimes only larger boulders remain visible today (*Figure 7.3*, *Figure 7.4*), the assumption being that stones from overlying courses were re-used elsewhere. The incorporation of large, earth-fast boulders into walls can be observed in standing stone walls today (*Figure 7.5*). Larger stones are also visible along lynchet edges, but again these may be the surviving remains from more substantial structures.

The loss of boundary material may have included not just stone but also earth. Cloddiau are stone-faced earthen banks with hedging plants often grown along their tops and are a distinctive boundary type found in northwest Wales. Today the tradition is mainly found in the lower-lying coastal areas on the mainland, particularly the Llŷn Peninsula (Byrne 1996), where its distribution is attributed by dry-stone wallers to less readily available stone (The Conservation Volunteers 2017). Similar 'stone hedges'[23] are found in Cornwall, and other areas of south-west England. Detailed boundary recording by archaeologists, particularly for cloddiau, is relatively rare given (or perhaps because of) their ubiquity. The regional historic environment record includes over 600 individual records in the study area with a boundary monument type described as a bank, ditch, wall, or boundary, of which approximately 80 are for cloddiau or clawdd (the singular form for cloddiau).

Detailed records have started to be included in archaeological assessments in the last few years; their distribution on lower-lying coastal areas along the northwest coast and the Llŷn Peninsula

[23] http://www.cornishhedges.co.uk/

reflects the distribution of upstanding remains (*Figure 7.6*). Cloddiau are generally identified as post-medieval in date, based on map regression from nineteenth-century estate maps, 1st edition Ordnance Survey or Tithe maps (Rees and Williams 2013, Evans et al. 2018, Oattes 2019).

Unfortunately, only a small number of cloddiau overlap with areas of early fieldscape transcription. A couple of examples[24] that do, close to Porthmadog, appear on the Penmorfa Tithe map of 1838 (Evans 2013). They form part of a group of eighteenth or early nineteenth-century boundaries that overlie earlier and more irregular land divisions that can be identified on the lidar models (*Figure 7.7*). The depiction of some cloddiau on the 1st edition Ordnance Survey map is interesting because they appear as closely spaced tree symbols. Further research may indicate continuity with underlying boundaries shown on the lidar models and possible earlier dates.

There are a small number of excavated boundaries from the first millennium BC that provide additional information about construction techniques and traditions. At Graianog, as described above, there is evidence for a possible hazel hedge growing along a lynchet tentatively dated to the fifth to second century BC. A wall recorded at Erw Wen had its outer facing made from large cobbles and a core of smaller stones. A similar technique was observed at Rhiwgoch, where the excavator identified a 'raised stone bank, and partly upstanding stone wall' measuring 1.5m wide (Kenney 2013). Although modern development had disturbed one end of the wall, Kenney thought it was probable that it continued to meet the roundhouse and was contemporary with it (as described above).

Targeted research and excavation at Cwm Cilio, Llanaelhaearn, revealed new information about an early field terrace, visible as a 2m high feature (Smith et al. 2018). Its height proved to be a combination of the natural slope and a stony bank created through the gradual accumulation of field clearance stones and soil. Unfortunately, the area of geophysical survey, site of the excavated trench, terrace and boundary all lie just outside the area with lidar coverage, so the results cannot be compared with the early fieldscape transcription. Smith noted that some of the major boundaries cross the contour at an angle, so that there is some terracing on cross-contour boundaries. This was noted for some of digitised lynchets in the study area, not all of which have their full length aligned with the contours.

A substantial terrace excavated at the west side of Muriau Gwyddelod, Harlech, was also found to be 'mainly illusory' because of the difference in natural slope on either side of the stony bank (Smith et al. 2018). At least three phases were identified: an earlier, neatly constructed stone bank made from

[24] PRN 36361, PRN 36362

small stones; irregular ('rough') stone facing; and larger boulders which formed a line along the crest of the bank. Similar processes of boundary renewal and maintenance have been observed elsewhere in Britain. Sections cut through lynchets in Cornwall, for example, have shown the burial of earlier stone walls, subsequent lynchet development and addition of later stone walls (Herring et al. 1993).

Focusing on the detailed construction and character of boundaries demonstrates their variety and complexity; although they may be stable for long periods of time, they are also subject to periods of renewal and change: processes and traditions which are often poorly understood. Even where there has been more intensive research, such as Cwm Cilio, Braich y Gornel and Muriau Gwyddelod (Smith et al. 2018), the results are equivocal and, like the settlement evidence, establishing reliable chronologies is challenging. Previous interpretations dividing 'prehistoric field systems' into either small sub-rectangular, terraced fields or irregular fields with no obvious terracing, and linking these differences to settlement nucleation (RCAHMW 1964, Smith 1999b, Waddington 2013), have to be reconsidered in this context.

Irregularity and terracing are characteristics that have been assessed as part of the early fieldscapes research presented in this thesis. Their distribution patterns do not support a simple two-type fieldscape model. Rather, analysis indicates that subsequent land-use is the dominant influence on boundary survival and form, through millennia of re-working and re-use. As Løvschal emphasises in her analysis of landscape and settlement divisions in northwestern Europe, they are *emerging* (my emphasis) boundaries, whose durability and physical prominence lent them a degree of inertia (Løvschal 2014a: 736). The later prehistoric and Roman land divisions in northwest Wales are best understood with this perspective in mind, and by analysing them as features with greater or lesser coherence with one another and subsequent (or occasionally, earlier) enclosure.

Geospatial techniques helped to guide this approach by identifying areas with greater survival and coherence, described as fieldscape integrity. The uplands and coast between Barmouth and Harlech included several local areas with densely clustered and well-preserved features. A similar concentration was observed along the north coast. Beyond these regional foci, fieldscapes with high levels of integrity were also found above Rowen, Llanbedr-y-cennin and Tal-y-bont in the Conwy valley; on the wooded slopes to the north and west of Llanllechid; in Dyffryn Nantlle, east of Llanaelhearn; the uplands above Morfa Bychan and Borth-y-Gest; and adjacent to the lake edge at Llyn Cwmystradllyn.

These regional and local foci provided a consistent approach for quantitative analysis of their topographic setting and field shape. The results suggest that boundary irregularity, measured using sinuosity as a proxy, owes more to the careful selection of location than models of contingent or unplanned land division implied in the two-type fieldscape model or other sociocultural evolutionary interpretations. Boundaries were built on slopes where sunshine is maximised. They were long-lived. And they were carefully positioned to reduce the impact of prevailing winds, their irregular shape a response to the varied exposure encountered in different microclimates. This may explain the alignment of some cross-contour lynchets, which started their life as raised banks or walls. It has parallels with the dominant orientation of roundhouse entrances towards the east and southeast, away from the prevailing wind (Ghey et al. 2007).

A breakdown of aspect for high sinuosity clusters in the Ardudwy area showed that the slopes (aspect) where there is evidence for land division were more varied than elsewhere, suggesting the two attributes may be associated with the subtle variations in boundary alignment that were responses to the microtopography. The pattern concurs with observations made by Smith when he describes the sinuous shape of some boundaries at Cwm Cilio as 'giving the impression of having developed in an organic manner rather than being laid out to an overall plan' (2018: 3.5).

Boundaries may not have originally or always 'enclosed' or defined land in the way that fields are generally understood to do so today. This is not to draw a direct relationship between the fragmentary survival of boundaries and their original form, but to highlight different practices and purposes. As Johnston argues, evidence for lynchets along boundaries and small stone-free terraces adjacent to roundhouses such as Cwm Ffrydlas, may relate to small gardens and have not been enclosed (Johnston 2005b: 214). Cultivation in areas like these and the gradual removal of stone into discrete piles ('cairns') and along plot edges set in motion similar patterns that developed as larger areas were planted with crops.

The ephemeral and low walls excavated at Braich y Gornel, Fronhill and Cwm Cilio were all interpreted by Smith et al. as early boundaries that were not designed to enclose or exclude stock (Smith et al. 2018: 6.3.2). This may not have been the case. Low boundaries did not need to represent functional barriers in the same way that they do in modern farming. As O'Brien (2009: 338) argues in his analysis of stone walls constructed in the first millennium BC in the Barrees and Cloontreem valleys, south-west Ireland, animals were constantly tended by shepherds or cowherds, and through repeated herding were habituated to certain pastures to prevent them straying. Low walls may have been an integral part of these hefting traditions, acting as guides for people and animals rather than fencing them in or out. Recent evidence from Cornwall suggests that low walls may have been long-lived: Optically Stimulated Luminescence profiling and dating (OSL-PD) showed that a stony bank at the core of a lynchet was constructed in the Middle Iron Age by cutting down into older Bronze Age soils and the authors conclude that the boundary remained fairly low until the early medieval period (Vervust et al. 2020: 14).

The similarity between the form of some surviving boundaries that can be identified on lidar models and those that are no longer visible, but which form part of coherent early fieldscape groups, suggests that they may have also have later prehistoric and Roman origins. The walls that partly survive at Rhiwen, for example, appear to radiate from a central enclosure (*Figure 7.8*); at Efail Castell, a substantial roundhouse settlement was incorporated into later field boundaries (*Figure 7.9*); and at Llecheiddior-Uchaf (*Figure 7.10*), and Rhostryfan (*Figure 7.11*), small and irregular fields follow the same pattern as earlier boundaries. There is a stark contrast between these long-lived land divisions, which appear 'of and on the ground', and the straight nineteenth and twentieth century boundaries that do not. Comparison with the late nineteenth century 1st edition Ordnance Survey maps highlights this particularly well in places such as Pentir (*Figure 7.12*) and land adjacent to the Conwy River (*Figure 7.13*), where the alignment of newly 'drawn' fields bear little or no relationship to topography. These are lines with power and meaning linked to disembodied concepts of ownership rather than any lived experience of place and the natural world.

Concluding comments

This chapter has broadened the interpretive scope of the thesis beyond the descriptive and geostatistical analysis presented in chapters 5 and 6, to consider aspects of early fieldscapes that were missing from these quantitative approaches.

The main source of evidence for dating boundaries and enclosures are the roundhouse settlements associated with them, many of which were not recognised on the 1m resolution lidar models or lie in areas without lidar coverage. They total more than 900 and their significance was discussed through analysis of the 39 excavated examples within the study area, six of which have radiocarbon dates. This demonstrated that beyond roughly dating roundhouses to between 1000 BC and 1000 AD, it was not possible to identify more specific chronological patterns. Roundhouses may have been built on their own or alongside other houses; they may have been used for just a few generations or much longer; and where several houses are identified in a group, they may or may not be synchronous with one another.

The poor chronological resolution for roundhouses and, by extension, the enclosures and boundaries associated with them, has important implications for their interpretation. Because it is not possible to compare when and for how long they were in use, it is also not possible to draw direct or causal links between changing settlement permanence and nucleation, or between agricultural intensification and settlement nucleation. As outlined in chapter 3, models that make these links are predicated on economic approaches that see land division as bound up with the process of agricultural intensification and increased sedentism.

In place of these assumptions, this chapter has focused on the materiality of boundaries, highlighting the variation in their physical form and the processes that resulted in their creation, use, re-use and eventual abandonment. It demonstrated the potential for developing a better understanding of stability and change through more detailed recording.

The published records for excavated boundaries were re-examined and discussed as part of this doctoral work. The results are consistent with the new geostatistical analysis of boundary form and character, which rejected previous two-type field system models: boundaries were not *either* small sub-rectangular, terraced fields *or* irregular fields with no obvious terracing, but could have more complex and varied biographies.

Table 7.1

Excavated settlement sites and dating summaries for study area, based on Waddington (2013: 89, figure 4.1) with additions

Name	Description	Chronological span	Reference (Waddington 2013)	NPRN	PRN	Scheduled Monument	With lidar coverage	Extant
Cyfannedd Fawr	Unenclosed single roundhouse	150 BC-AD 220	GM150	-	4907	-	Part	No
Crawcwellt West	Unenclosed scattered roundhouses	800 BC-50 AD	GM137	307141	5163	-	Yes	Yes
Hengwm	Unenclosed scattered roundhouses	370-90 BC	GM186	55595	33549	-	No	No
Erw Wen	Enclosed settlement - concentric Circle	980-400 BC	GM55	302760	1036	ME188	No	Part
Moel y Gerddi	Enclosed settlement - concentric Circle	800-200 BC	GM76	15499	1003	-	No	No
Rhiwgoch	Enclosed settlement	Construction between 85 BC and AD 60, going out of use by AD 85-250	-	-	29854	-	No	No
Graianog East[25]	Polygonal enclosures	200 BC-AD 390	GD67	-	117	-	Yes	No
Conwy Mountain	Hillfort	750-200 BC	AB5[26]	95279	2816	CN012	Part	Yes

[25] Reference corrected from Waddington (2013), which incorrectly identifies the site as Graeanog II
[26] Reference corrected from Waddington (2013)

Table 7.2

Excavated settlement evidence and dating summaries for northwest Wales (outside study area), based on Waddington (2013: 89, figure 4.1)

Name	Description	Chronological span (summarised by Waddington 2013)	Reference (Waddington 2013)
Parc Bryn Cegin E	Unenclosed single roundhouse	800-400 BC	GA200
Parc Bryn Cegin F and G	Unenclosed nucleated roundhouse group	500 BC-AD 75	GA198
Cefn Du	Unenclosed nucleated roundhouse group	400 BC-AD 320	AN65
Cefn Cwmwd	Unenclosed nucleated roundhouse group	400 BC-400 AD	AN64
Melin y Plas	Unenclosed nucleated roundhouse group	100 BC-AD 220	AN76
Mellteyrn Uchaf	Enclosed settlement - concentric Circle embanked	1410-760 BC	GD77
Llandygai B	Enclosed settlement - circular enclosure	1210-970 BC	GA70
Llandygai A	Enclosed settlement - circular enclosure	830-660 BC	GA69
Ty Tan Dderwen	Enclosed settlement - circular enclosure	400 BC-AD 100	GM84
Bryn Eryr	Enclosed settlement – rectangular embanked	800 BC-AD 400	AN22
Parc Bryn Cegin N	Enclosed settlement – curvilinear embanked	390 BC-AD 320	GA80
Ty Mawr	Curvilinear enclosures	285-85 BC	AN55
Llanbedrgoch	Curvilinear embanked added wall	AD 620-1040	AN41
Castell Odo	Double ringwork hillfort	800-200 BC	GD12
Meillionydd	Double ringwork enclosure	753-203 BC	GD22
Bryn y Castell	Hillfort	370 BC-AD 200	GM2
Pen y Dinas (Great Orme)	Hillfort	400-210 BC	AB11
Gwinllan Glan Morfa site A	Unclassified settlement	AD 50-110	GD309

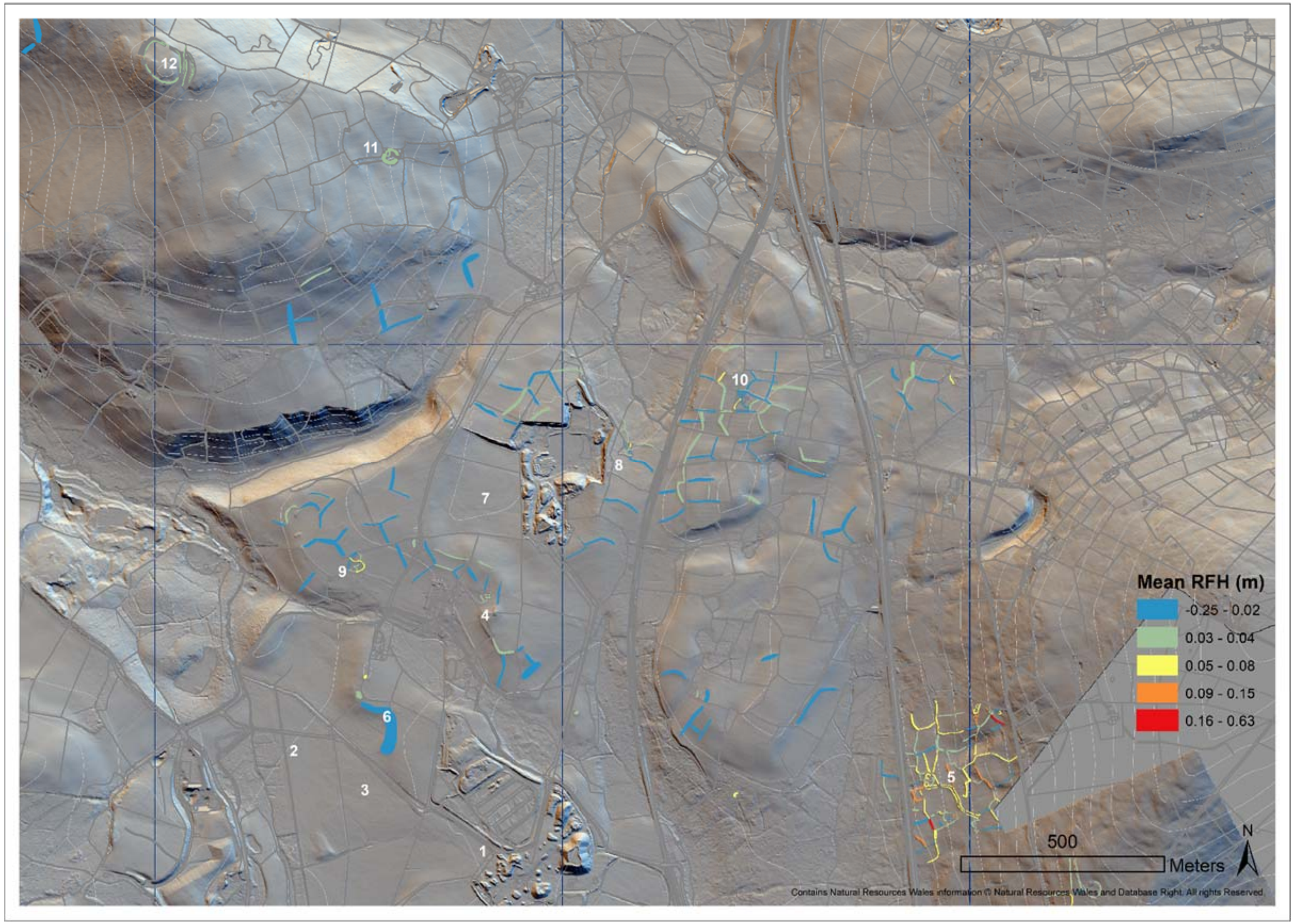


Figure 7.1
Mean Relative Feature Height (RFH), Graianog, shown at 1:10,000 (see overleaf for key)

Map reference	Site name	HER reference (PRN)
1	Cefn Graianog I roundhouse settlement (excavated and destroyed)	122
2	Cefn Graianog West (excavated and destroyed)	120
3	Cefn Graianog II roundhouse settlement (excavated and destroyed)	116
4	Graianog East roundhouse settlement (excavated)	117
5	Caerau roundhouse settlements and fields	108
6	Middle Iron Age lynchet (excavated and partially destroyed)	226
7	Area of stone banks and narrow ditch (partially excavated)	12068
8	Roundhouse settlement (unexcavated)	3999
9	Roundhouse settlement northwest of Graianog Farm (unexcavated)	118
10	Roundhouse settlement (unexcavated)	121
11	Roundhouse settlement, south-west of Foel Uchaf (unexcavated)	193
12	Y Foel hillfort (unexcavated)	203

Figure 7.2
Stone-faced boundary, (left) and boundary edge and lynchet (right)

Figure 7.3
Stone ‘grounders’ in boundary wall partly covered in peat, Waun Llanfair

Figure 7.4
Boundary wall, Moel Faban

Figure 7.5
Boundaries and terraces, Llanllechid

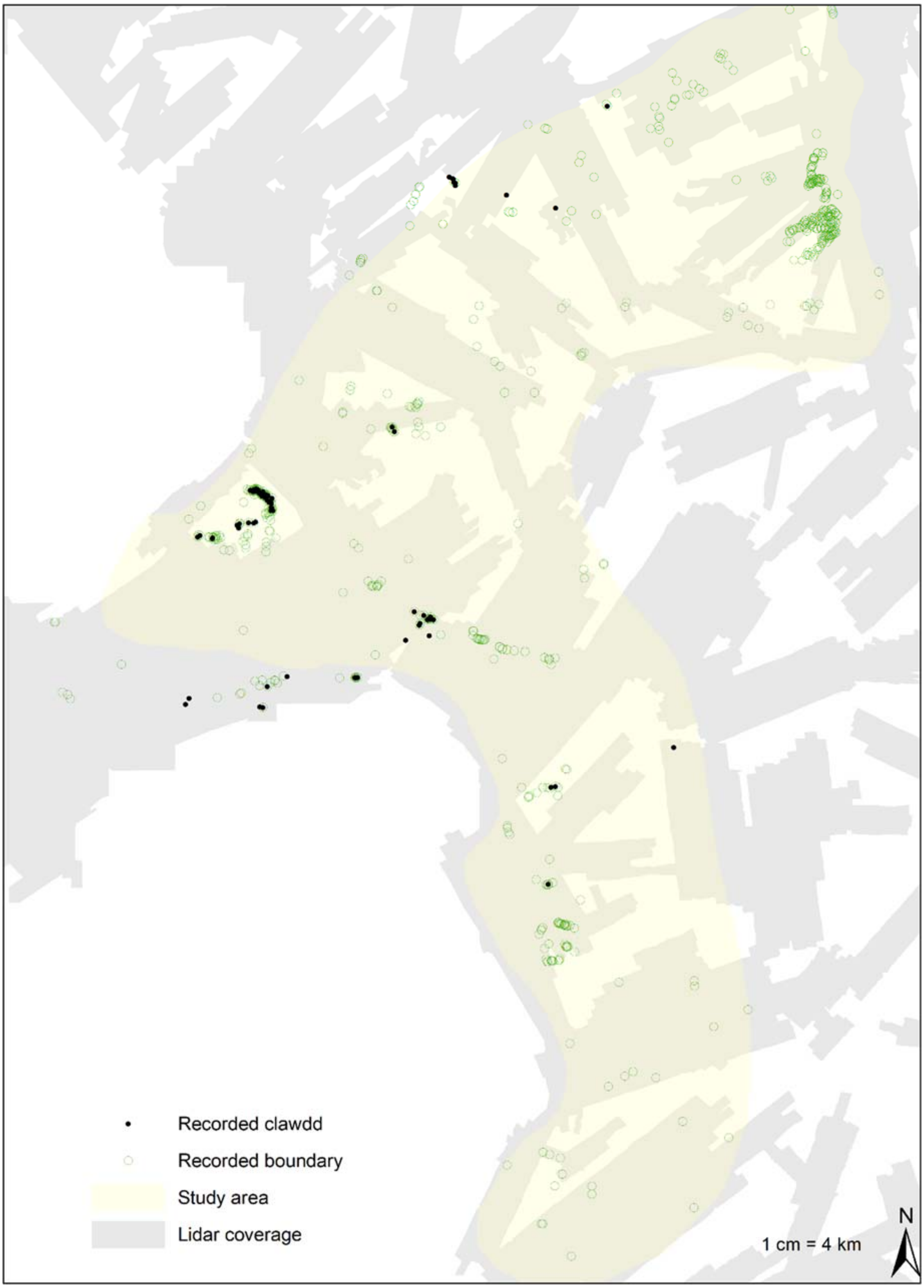


Figure 7.6
Distribution of boundary records included in the regional HER, including cloddiau

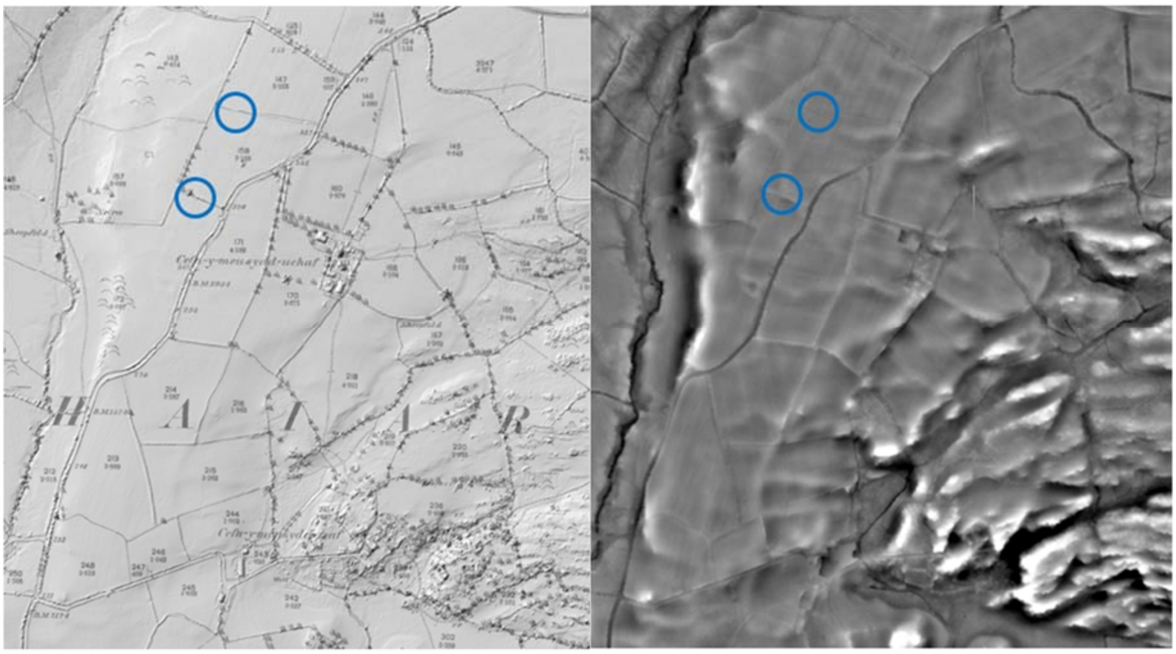


Figure 7.7
Penmorfa, Porthmadog, shown at 1:5,000

Comparison between digital *surface* lidar model overlain by the 1st edition Ordnance Survey map (a) and simple local relief lidar model (b), with location of two known cloddiau marked by blue circles. These are rare examples where eighteenth or early nineteenth-century boundaries overlie earlier, smaller, and more irregular land divisions that can be identified on the lidar models. The evidence that the cloddiau were continuous with the earlier boundaries is ambigious.

See Appendix K, transcription map 14 for context
Centred on grid reference: 25250 34040

1:2500 County Series 1st edition [TIFF geospatial data], Scale 1:2500, Tiles: caer-sh5240. Updated 30 November 2010, Historic, Using EDINA Historic Digimap Service, <http://digimap.edina.ac.uk>, Downloaded: 2018-02-02 15:25:56.039

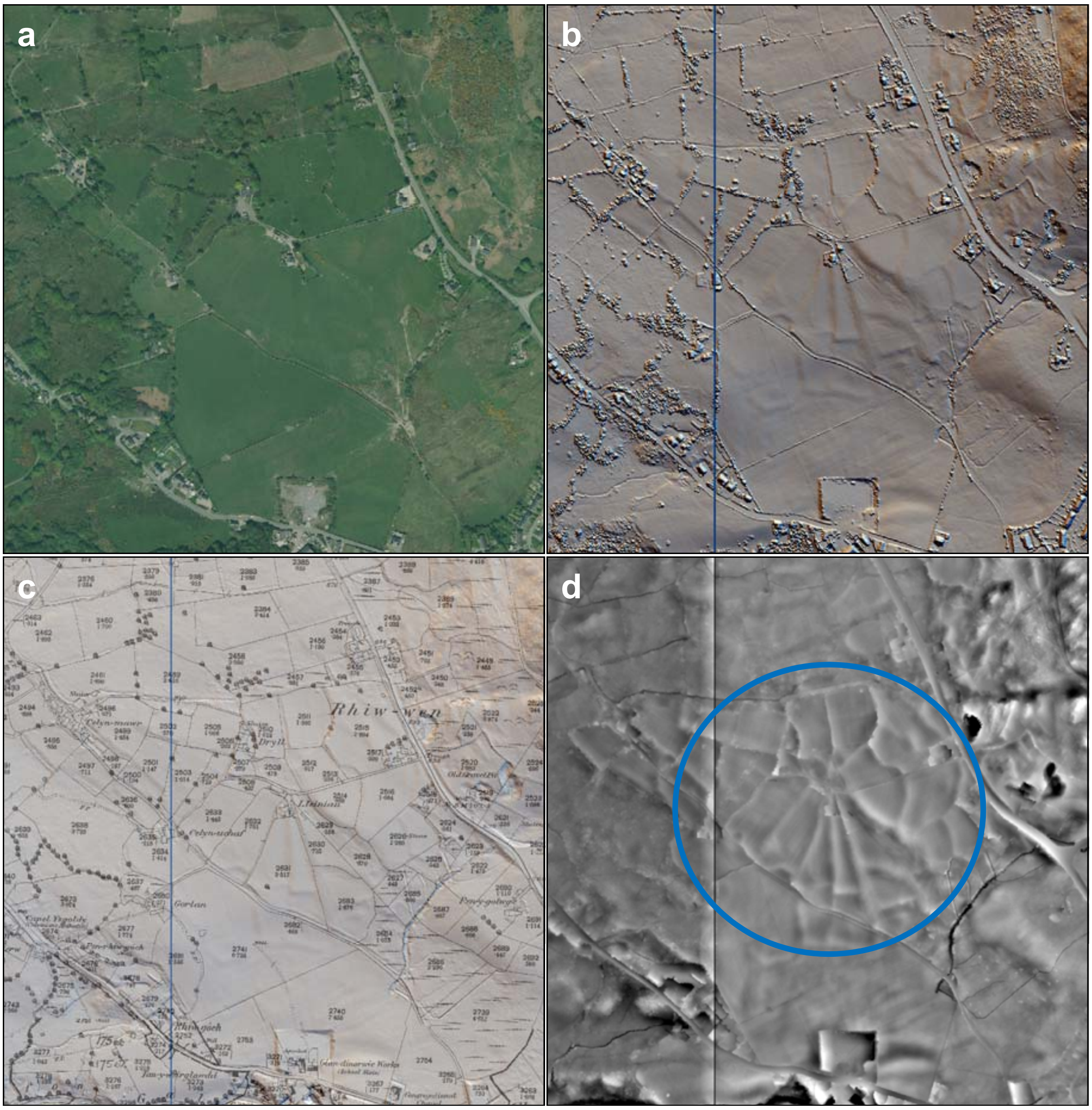


Figure 7.8
Rhiwen, Deiniolen, shown at 1:10,000

Comparison between vertical aerial photograph taken in 2016 (a), digital *surface* hillshade lidar models (b), digital *terrain* hillshade lidar model overlain by the 1st edition Ordnance Survey map (c) and simple local relief lidar model.

Partly surviving walls radiate from a central, well-preserved enclosure (blue circle). Continuity is evident for existing and recently lost boundaries, where the similarity with early banks suggest longevity.

See Appendix K, transcription map 6 for context
Centred on grid reference: 25715 36553

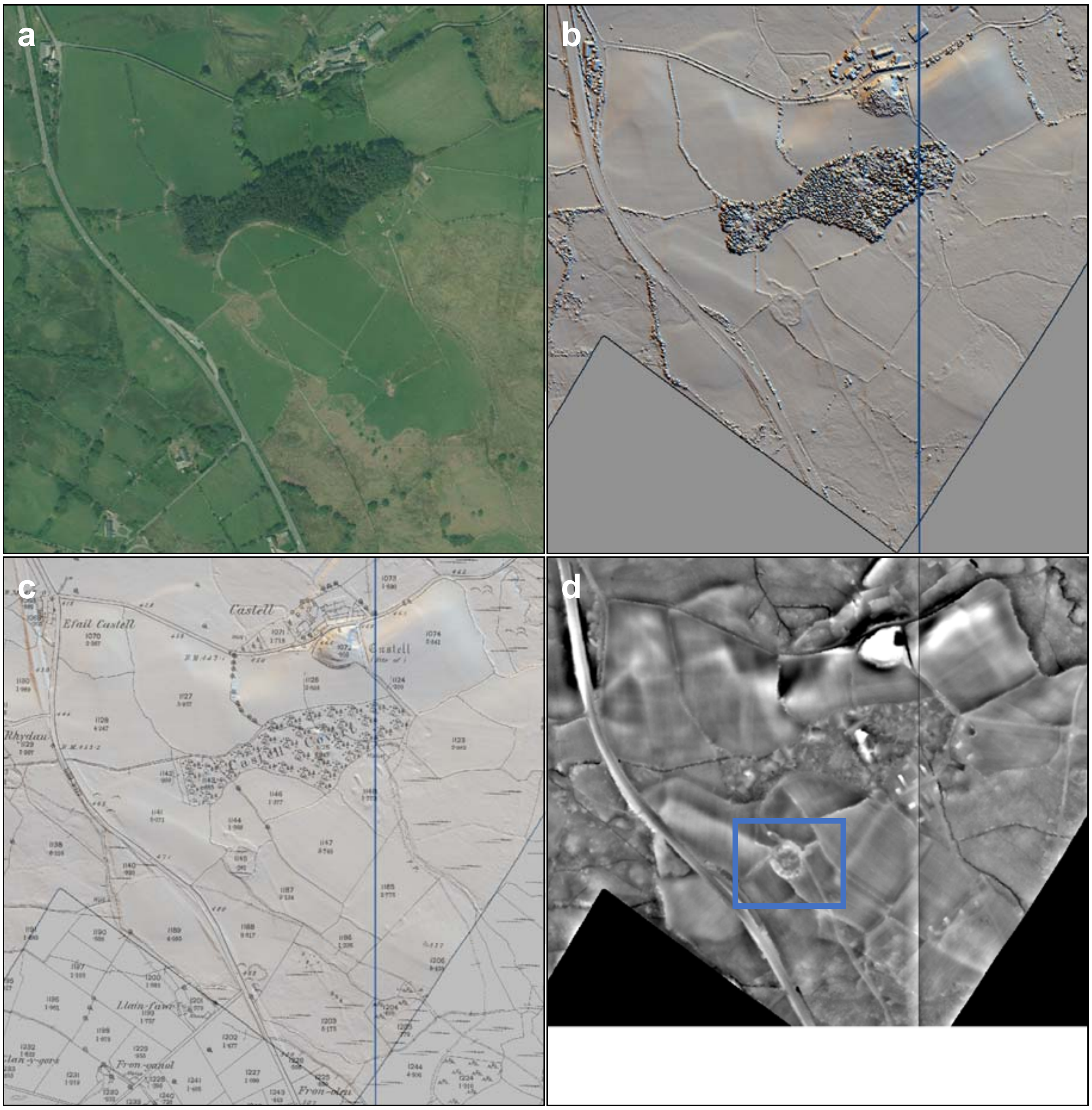


Figure 7.9
Efail Castell, Rhiwlas, shown at 1:10,000

Comparison between vertical aerial photograph taken in 2016 (a), digital *surface* hillshade lidar models (b), digital *terrain* hillshade lidar model overlain by the 1st edition Ordnance Survey map (c) and simple local relief lidar model (SLRM).

A substantial roundhouse settlement is easy to spot on the SLRM (see blue box), with several roundhouses incorporated into the enclosure wall. A larger number of boundaries appear to survive on the less improved land to the south.

See Appendix K, transcription map 6 for context
Centred on grid reference: 25680 36530

Aerial photograph, 2016. 1:2500 County Series 1st edition [TIFF geospatial data], Scale 1:2500, Tiles: caer-sh5664, caer-sh5764, caer-sh5665, caer-sh5765. Updated 30 November 2010, Historic, Using EDINA Historic Digimap Service, <http://digimap.edina.ac.uk>, Downloaded: 2018-02-02 15:25:56.039

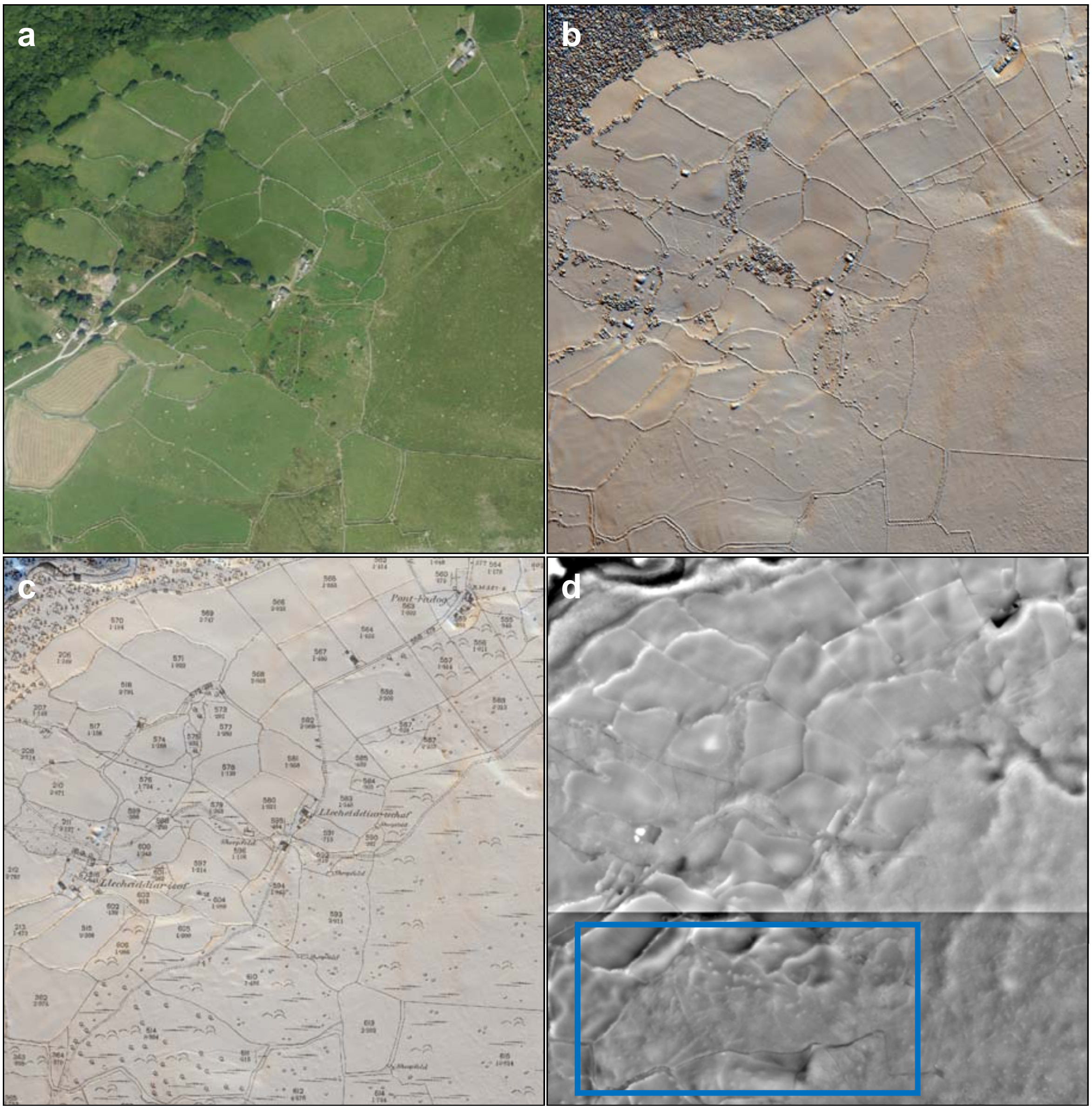


Figure 7.10
Llecheiddior-Uchaf, shown at 1:10,000

Comparison between vertical aerial photograph taken in 2016 (a), digital *surface* hillshade lidar models (b), digital *terrain* hillshade lidar model overlain by the 1st edition Ordnance Survey map (c) and simple local relief lidar model.

Small and irregular fields follow the same pattern as earlier boundaries, indicating longevity, with evidence for lost boundaries visible on the marshy, unimproved land to the south (blue box).

See Appendix K, transcription map 19 for context
Centred on grid reference: 26050 32210

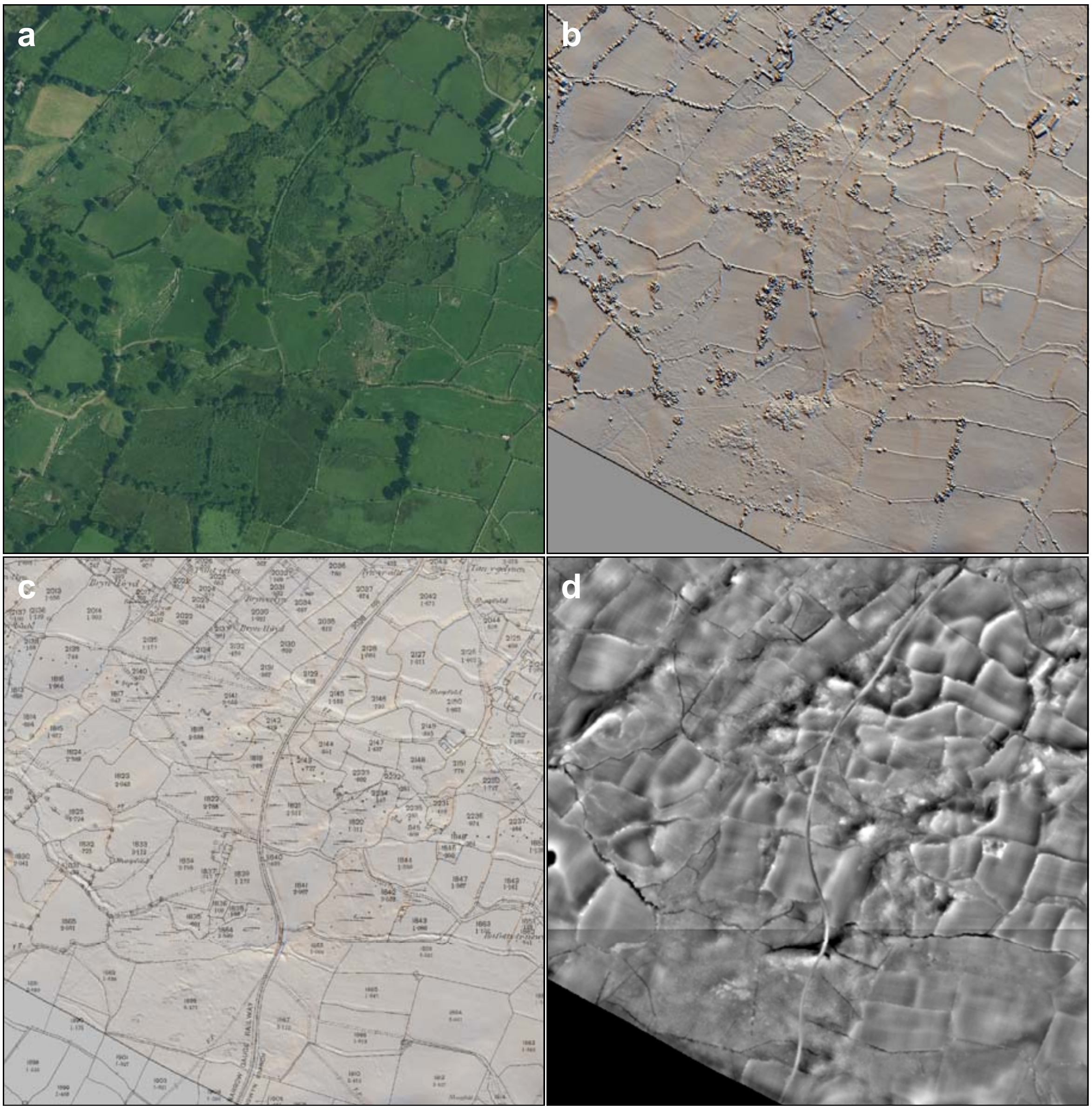


Figure 7.11
Rhostryfan, shown at 1:10,000

Comparison between vertical aerial photograph taken in 2016 (a), digital *surface* hillshade lidar models (b), digital *terrain* hillshade lidar model overlain by the 1st edition Ordnance Survey map (c) and simple local relief lidar model.

A dense concentration of small and irregular fields mirror the pattern of earlier boundaries, indicating continuity and longevity.

See Appendix K, transcription map 5 for context
Centred on grid reference: 24950 35710

Aerial photograph, 2016. 1:2500 County Series 1st edition [TIFF geospatial data], Scale 1:2500, Tiles: caer-01613, caer-02101. Updated 30 November 2010, Historic, Using EDINA Historic Digimap Service, <http://digimap.edina.ac.uk>, Downloaded: 2018-02-02 15:25:56.039

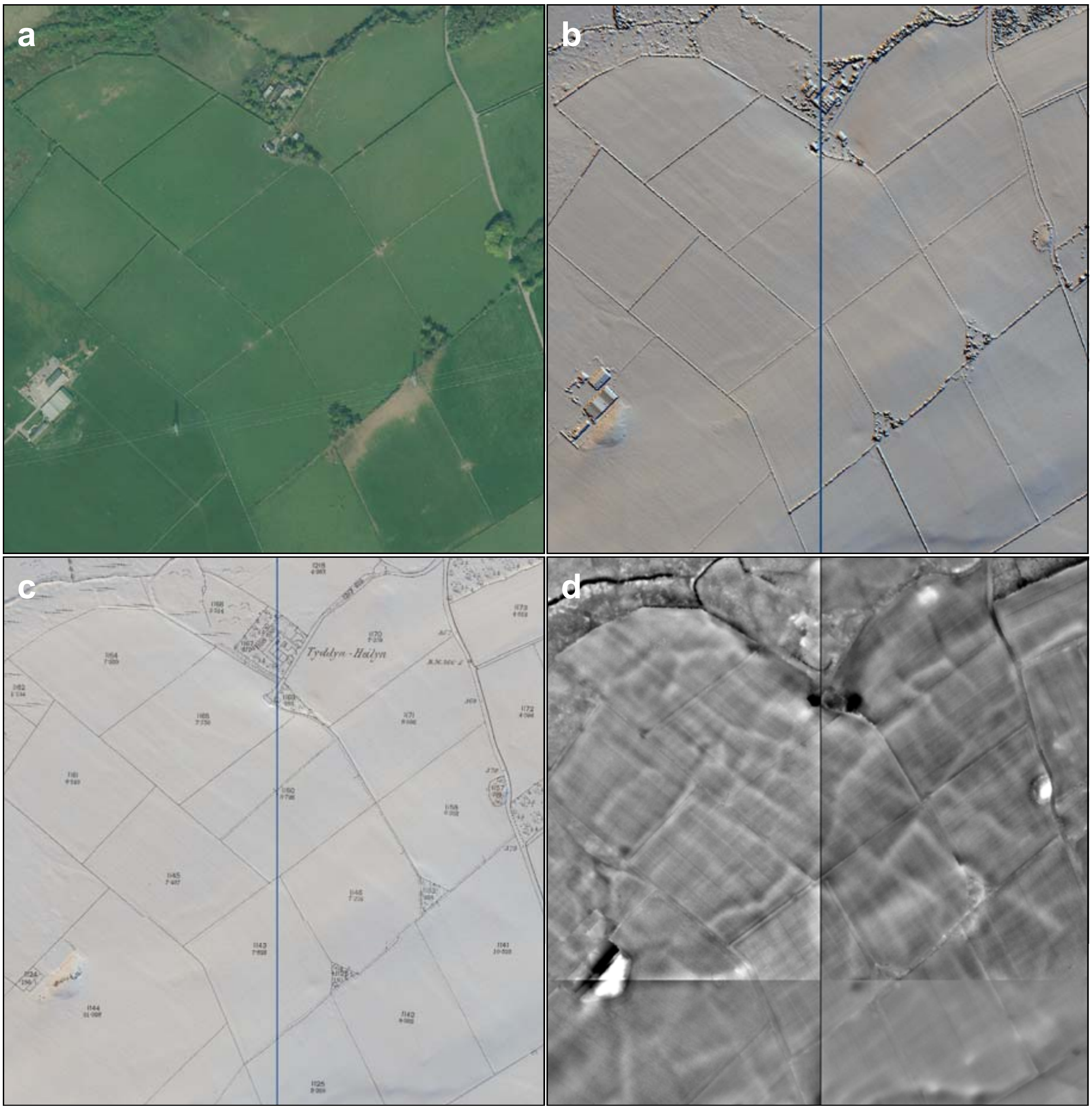


Figure 7.12
Pentir, shown at 1:10,000

Comparison between vertical aerial photograph taken in 2016 (a), digital *surface* hillshade lidar models (b), digital *terrain* hillshade lidar model overlain by the 1st edition Ordnance Survey map (c) and simple local relief lidar model.

The comparison between the field boundaries depicted on the late nineteenth century 1st edition Ordnance Survey maps and lidar models demonstrate that the alignment of newly 'drawn' fields bear little or no relationship to topography.

See Appendix K, transcription map 1 for context
Centred on grid reference: 25700 36810

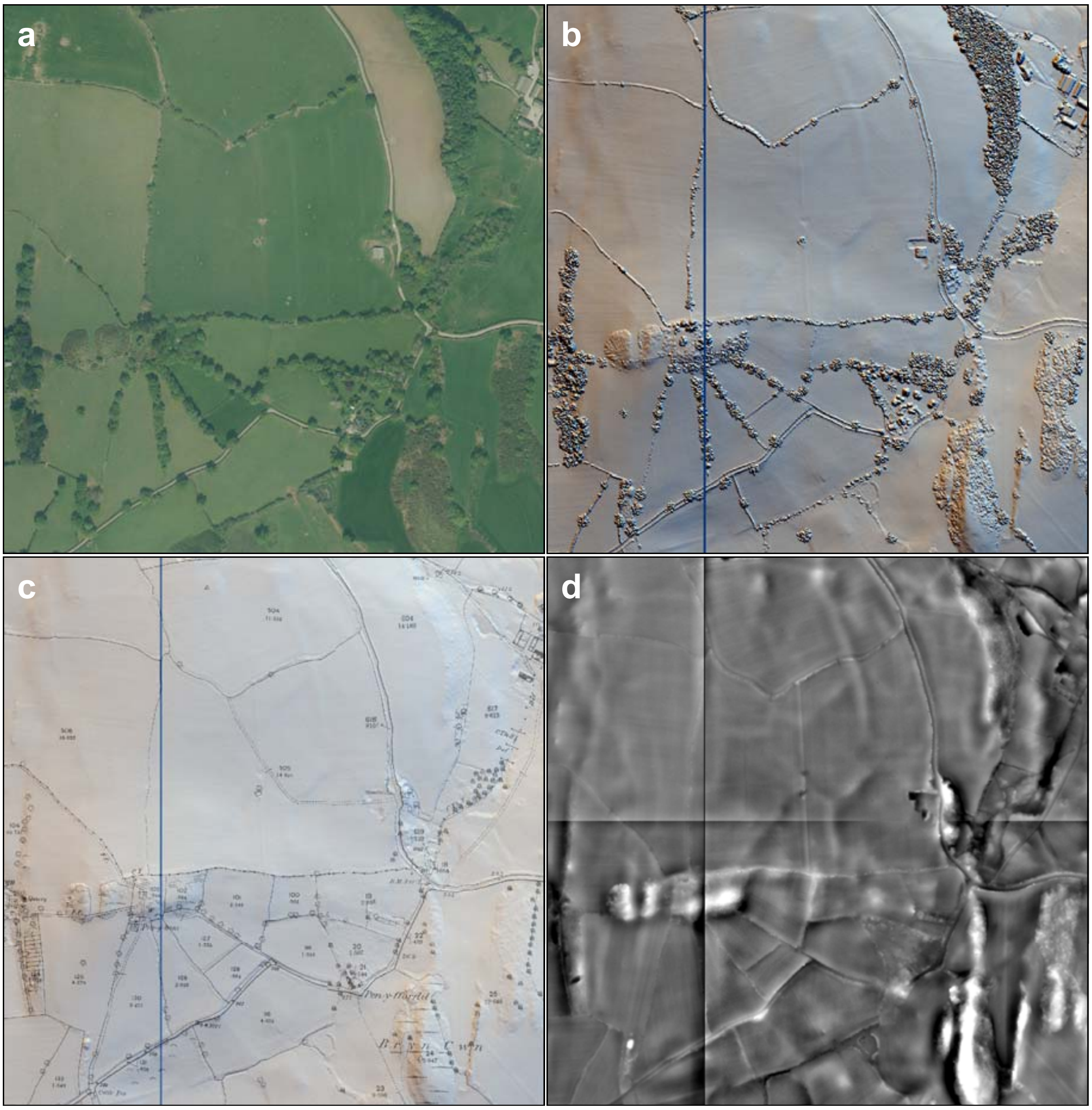


Figure 7.13
Conwy Valley, shown at 1:10,000

Comparison between vertical aerial photograph taken in 2016 (a), digital *surface* lidar models (b), digital *terrain* lidar model overlain by the 1st edition Ordnance Survey map (c) and simple local relief lidar model.

The comparison between the late nineteenth century 1st edition Ordnance Survey maps and lidar models shows the loss of many earlier boundaries to the north of the enclosure at Penx.

See Appendix K, transcription map 3 for context
Centred on grid reference: 27810 37300

Aerial photograph, 2016. 1:2250

0 County Series 1st edition [TIFF geospatial data], Scale 1:2500, Tiles: caer-sh7752, caer-sh7773, caer-sh7872, caer-sh7873. Updated 30 November 2010, Historic, Using EDINA Historic Digimap Service, <http://digimap.edina.ac.uk>, Downloaded: 2018-02-02 15:25:56.039

Chapter 8
Snowdonia's Early Fieldscapes

Early fieldscapes: human and environmental influences

The quantitative and qualitative results presented in three preceding chapters have revealed distinctive patterns of early land enclosure and settlement in northwest Wales spanning a period between 1000 BC and AD 1000. This chapter considers how they might be explained by human and environmental processes. This is particularly difficult in northwest Wales because so little is known about subsistence practices and their relationship to land tenure.

The discussion is heavily dependent on palaeoenvironmental evidence. This has primarily been collected from contexts where plant rather than animal remains survive best and analysis has focused on pollen. No relevant studies of land snails or insects have been identified during this research. The rarity of faunal remains is particularly problematic given the assumed importance of pastoralism, with analysis dependent on inference from plant remains rather than direct skeletal evidence of domesticated species. In addition, as Caseldine notes (Smith et al. 2018: 20), palaeoenvironmental work associated with early field systems has been largely neglected in Wales compared to other areas in Britain and Ireland.

The evidence can be split into three broad groups: targeted geomorphological and palynological investigation of vegetation history; targeted palaeoenvironmental studies designed to inform the interpretation of excavated archaeological sites; and opportunistic palaeoenvironmental work that has arisen from excavations where there are suitable conditions or surviving deposits, often in development-led contexts.

The earliest research was carried out in the uplands by quaternary specialists with an interest in the late glacial and early Holocene vegetation recovery (Seddon 1962, Burrows 1974, Hibbert and Switsur 1976, Walker 1978). The first targeted palaeoenvironmental studies that accompanied archaeological excavation were focused on second and first millennium BC agricultural practices and climate change (Mighall and Chambers 1989, Chambers and Lageard 1993, Mighall and Chambers 1995, Mighall and Chambers 1997, Botterill and Chambers 1998, Middleton 1998, Crew and Mighall 2013). Development-led studies have become more common in the last couple of decades (Akeret 2006, Schmidl et al. 2008, Kenney and Parry 2013, Kenney et al. 2013, McKenna 2016).

The cross-over between quaternary and archaeological research traditions has increased over time, with a greater shared interest in understanding anthropogenic influences. The main studies with evidence that can be dated from the second millennium BC to the first millennium AD, are summarised in Table 8.1 (*Figure 8.1*).

Synthetic and regional overviews have drawn on these studies to chart a broad shift from post-glacial closed woodland to open landscapes. This is attributed to extensive woodland clearance that accelerated during the Iron Age and continued into the Roman period, with episodes of regeneration (Rippon et al. 2015). Cultivation and farming is set against a climatic backdrop of deteriorating or improving conditions (e.g. Mason et al. 1998, Waddington 2013, Rippon et al. 2015), specifically wetter and colder periods between the thirteenth and twelfth centuries BC, in the ninth century BC (Amesbury 2008), and between the fifth to ninth centuries AD (Davies 2001). However, as Waddington notes in her review of settlements, climate models are not defined for North Wales and where information is available at site level, there are not enough dates to tie environmental change to settlement chronologies (2013: 14). In addition to these uncertainties, the relationship between past human activity and Holocene climatic variability is, as neatly described by Stastney, 'non-linear' (2020: 1).

In summary, there are numerous and interrelated challenges for understanding changing subsistence strategies: the reliance on pollen and, to a lesser extent, plant macrofossil studies, the virtual absence of animal remains, varied palaeoenvironmental research traditions and research goals, the complex relationship of climate to past human activity, and of vegetation history to human management and modification of the landscape. In the light of this, the approach adopted in the following section relates the principal palaeoenvironmental sites to high integrity fieldscapes identified through the geostatistical analysis presented in chapter 6 (*Figures 6.11* and *6.12*).

The uplands of the Carneddau and associated coastal lowlands

The northern part of the study area has the largest number and best quality sources of information, most notably palaeoenvironmental research carried out in the upper Aber Valley (Hughes and Grant 2005, Woodbridge et al. 2012), the upland plateau above Llanfairfechan (Caseldine et al. 2017) and lower lying Arfon Platform (Watkins et al. 2007). The palaeoenvironmental studies are summarised in Table 8.1 and shown on figure 8.1 (sites 1-6).

The proximity of fieldscape features to these sampling sites demonstrates the potential to relate land division to vegetation histories, and to compare sequences that are close to one another but from different topographic areas.

Three clusters of high sinuosity boundaries (Figure 6.26, sites b-d) lie within a few kilometres of the sampling sites in the Woodbridge et al. (2012) study, which set out to explore the spatial dimensions of vegetation changes in the upper Aber Valley. An altitudinal transect approach was adopted, involving sampling from five sites within a small area. Although temporal resolution was limited by the number of radiocarbon dates, the vegetation sequences displayed broad similarities. All site assemblages were dominated by arboreal pollen early on (alder, birch, hazel and oak, with low values of elm), roughly dated to the third and second millennium BC. Between about 1000 BC and AD 1000, woodland species were replaced by open grassland and herbaceous taxa. These patterns were found across all sites, including those above 500m elevation, indicating human land use and clearance in the high uplands.

These results are consistent with the early fieldscape patterns and use of slope identified in this thesis. Although boundary alignments vary considerably across the different high sinuosity boundary groups (Figures 6.27 and 6.28), geostatistical analysis demonstrates that they developed in a similar way, constructed on sunnier slopes, along and across slopes to mitigate the effect of prevailing winds. Slope and altitude were not critical influencing factors, which suggests small-scale cultivation of richer soils following woodland clearance and incremental boundary construction.

The palaeoenvironmental study also identified significant differences for sampling sites. At lower altitudes the disappearance of alder, birch and hazel was abrupt, whereas at higher altitudes the decline was more gradual. Abrupt declines in woodland are indicative of tree clearance close to the sample site and Woodbridge et al. (2012: 91) attributed this pattern to the proximity of several prehistoric roundhouses and the associated impact of human occupation on vegetation. It is worth noting the likelihood that many settlements, particularly where roundhouses were built from wood, have not been identified and may have been occupied for relatively short periods of time. As discussed in chapter 7, evidence from southern Britain and parts of Europe suggest relatively short-term neolocal residence patterns (Brück 1999, Roymans and Theuws 1999, Wickstead 2007).

At higher altitudes (between 400m and 600m elevation), the pollen assemblages indicated continuous pastoral human land use, with evidence of clearing, burning and grazing throughout the last 6,000 years. Tree growth was limited at higher altitudes and resulted in a more open landscape, whereas woodland persisted on lower ground into the later Holocene. Exposure to prevailing winds was also an influential factor for patterns of vegetation growth, with localised stands of alder in sheltered locations. There is no evidence for land being abandoned for long periods of time and Woodbridge et al. argue that it is more likely climatic shifts led to changes in human land management.

A second upland study was undertaken approximately 6km to the north-east of the upper Aber Valley, on a broad, gently sloping moorland basin above Llanfairfechan, known as Waun Llanfair (Caseldine et al. 2017). The site is shown on Figure 8.1 (site 3). The aim of this work was primarily to assess the setting of an unusual concentration of funerary and ritual monuments dating from the Neolithic and Bronze Age, including the Cefn Coch stone circle[27], two large ring cairns and the Graiglwyd stone source (axes), which was quarried from the first half of the fourth and third millennia BC. Three pollen columns were obtained from shallow peaty deposits in the area, and samples and small columns taken from buried ground surfaces associated with excavations adjacent to a buried stone wall, two burnt stone mounds and two cairns.

Like the upper Aber Valley, the third millennium BC assemblages for these samples were dominated by arboreal pollen. Alder appeared most frequently on wetter soils and higher, drier land was populated by hazel and birch woodland. However, by the later second millennium BC the area was more open and peat deposits had developed on the plateau to the east, changes that Caseldine et al. (2017: 129) attribute to two phases of clearance associated with quarrying at Graiglwyd and activity close to the funerary monuments. Pastoral activity is suggested by herbaceous taxa indicative of grassland and the presence of fungal spores indicative of animal dung. There is also tentative evidence for cultivation of barley.

This pattern of land use appears to change in the first millennium BC. An increase in heather communities, birch woodland and pollen of pondweed and *Sphagnum* moss is linked to major climatic shifts that resulted in cooler and wetter conditions. This may have occurred between the fourteenth to twelfth century BC *or* in a ninth century BC Sub-boreal/Sub-atlantic climatic event, which was characterised by reduced solar activity (Amesbury 2008 quoted by Caseldine et al. 2017). The presence of sedge, rush and buttercup seeds also indicate a climatic shift to cooler and/or wetter conditions or changes in hydrology in the area as a result of human activity or a combination of both. Soil deterioration may have caused the cessation of upland cereal growing, along with reduced pastoral activity, both of which are interpreted as part of a possible shift to lowland sites and seasonal use of the uplands (2017: 126).

This thesis has been tested by comparing the uplands with the coastal lowlands to the southwest, where two overlapping cores were taken from the centre of a small lake, Llyn Cororion (Watkins et al. 2007). According to the authors, its size (0.68 ha) and topographic setting meant that the pollen assemblages are likely to reflect plants growing within a few kilometres. They indicate that human activity had a major influence on vegetation development, particularly after about 1250 BC. Watkins

[27] The site is also known by its English name, the Druid's Circle

et al. (2007: 179) conclude that anthropogenic fire and agricultural activity probably prevented tree regeneration and were a major cause of woodland loss, particularly after the seventh century BC. All the major tree taxa declined rapidly between the third to first centuries BC, suggesting extensive and deliberate clearance, with cereal grains indicating arable cultivation as a component of farming within the catchment.

An area of early boundaries on the lower-lying Arfon plateau is located within a couple of kilometres of Llyn Cororion. Wide, ploughed-out banks lie adjacent to or, in one case, possibly underlying the route of a Roman road and can be distinguished from upland boundaries by their lower sinuosity and more regular, roughly rectangular layout. They lie on slopes a short distance to the north of two small hillforts at Pendinas and Caer Pencraig, both which are less than 1.5km from Llyn Cororion. It seems reasonable to assume that the land division that survives close by is likely to have been associated with the cultivation of these crops.

Additional information about the variety of first millennium BC crops was uncovered at Parc Bryn Cegin, located a couple of kilometres north of Llyn Cororion (Schmidl et al. 2008). In spite of poor preservation of biological remains, most features associated with the roundhouses contained evidence of cereal remains and the presence of weeds associated with cultivated ground. A significant assemblage of charred plant remains recovered from a central feature in one of the roundhouses (roundhouse A) indicated that spelt wheat was the most abundant crop; other species such as barley, emmer wheat, naked wheat and oat were also recovered (Kenney 2008a). Unfortunately, the contexts for these finds could not be confidently linked to the main settlement phases and were therefore only roughly attributed to the later first millennium BC.

Watkins et al. (2007), Woodbridge et al. (2012) and Caseldine et al. (2017) all emphasise that although the broad sequence of environmental change follows trends recorded elsewhere in North Wales, in this topographically diverse region local conditions play a significant role in the pattern and timing of vegetation change. These include edaphic and groundwater conditions, coastal proximity, altitude, aspect, exposure to winds *and* human activity. This fits well with the model of incremental boundary construction and intermittent use suggested by the analysis presented in this thesis.

By contrast, more sinuous and better-preserved boundaries are concentrated in a handful of areas in upland locations, again close to palaeoenvironmental sampling sites at Cors Wern Goch and Waun Llanfair. The clusters located at Garreg Fawr, east Coed Gorddinog, Anafon and Cae’r Mynydd, also lie close to or on Roman roads and are all within a couple of kilometres of one of three hillforts along this coastal strip, Maes y Gaer[28] hillfort above Abergwyngregryn, Dinas Camp[29] above Llanfairfechan and Braich y Dinas Hillfort[30] above Penmaenmawr.

Because there are no dates for boundaries in either upland or lowland contexts, the relationship of these different phases of intensified woodland clearance to the development of land divisions and shifting patterns of pastoralism cannot be assessed.

Lower lying coastal strip to the west of Snowdonia

The vegetation history of land to the south of the Arfon Plateau is less well understood than the Carneddau, particularly for the fieldscapes that survive around Rhostryfan. The closest palaeoenvironmental evidence to these features is from a development-led excavation in Caernarfon, located within a few hundred metres of Segontium Roman fort. The site, known as Ysgol yr Hendre (Kenney and Parry 2013), has produced the most accurately dated palaeoenvironmental remains in the study area (Table 8.1 and *Figure 8.1*, site 7). The application of Bayesian modelling to radiocarbon dated charcoal samples from a group of ovens showed that they were first used within the time interval *cal* AD 25–80 (95% probability) or *cal* AD 50–75 (68% probability), that is, during the initial construction of the fort in c. AD 77 (Kenney and Parry 2013: 31).

The charcoal remains showed the selection of several species native to Britain including ash, elm and willow, with oak and hazel being most frequently used as firewood. The palaeoenvironmental specialist, Rosalind McKenna, concluded that the assemblage indicates an oak woodland close to the site (2013: appendix 111.7). She also noted the similarity between samples from various features dating from the Neolithic to medieval periods and suggests continuity rather than change was a key feature of the vegetation history of the area.

Palaeoenvironmental evidence has been recorded at three sites further south (Table 8.1 and *Figure 8.1*, sites 8-10): from pollen cores and buried soil deposits at Graianog (Botterill and Chambers 1998, Chambers 1998), Cefn Graianog (McKenna 2016) and Cwm Cilio (Smith et al. 2018). These studies have been discussed above, being rare examples where early boundaries, settlement and palaeoenvironmental evidence are found together. Unfortunately, problems with dating from these sites make it difficult to link vegetation histories with changes in subsistence practices and emerging land division. The calibrated radiocarbon dates[31] for the core at Cwm Cilio, for example, do not agree

[28] PRN 230, Scheduled Monument CN038
[29] PRN 392, Scheduled Monument CN049
[30] PRN 712, destroyed by quarrying in the first half of the twentieth century
[31] 800±30 uncalibrated BP, AD 1180-1280 (Beta-312794) at 115-97cm depth, overlain by 1940±30 uncalibrated BP, AD 10-205 (Beta-360404) at 97-74cm depth, overlain by 910±30 uncalibrated BP, AD 1040-1215 (Beta-312793) at 74-56cm.

with the stratigraphic sequence (Smith et al. 2018). The reason for this was not resolved: it could be an erroneous measurement, residual material, disturbance, or inversion of the sediment in the core. There are similar issues with chronology at Graianog where pollen assemblage phases are not securely dated (Botterill and Chambers 1998, Chambers 1998) or, in the case of recent work at the quarry, there are no radiocarbon dates (McKenna 2016).

Fieldscapes north of Criccieth

Braich y Gornel (Table 8.1 and *Figure 8.1*, site 11) is the second of three sites that were studied in detail as part of recent work focused on prehistoric field systems in North Wales (Smith et al. 2018). A roundhouse settlement lies at the centre of an area of small fields, on south-east facing slopes close to the shore of Llyn Cwmystradllyn. Excavation in 1950 and 1953 revealed the stone foundations of two roundhouses and a smaller rectangular building situated between them (Gresham 1972). The recent fieldwork programme sought to provide better dating evidence, absent from the original excavation. Trial trenching across one of the early field boundaries produced a charcoal sample dated to between the thirteenth and eleventh centuries BC[32] but no first millennium dates. Geophysical survey also revealed evidence for two small fields adjacent to the roundhouse settlement, and faint linear anomalies within one of them, which the authors suggest could indicate a cultivation phase (Smith et al. 2018).

No second or first millennium dates were obtained from the peat column taken 200m north-east of these early fields. In common with palaeoenvironmental work at Cwm Cilio, the value of the pollen analysis at Braich y Gornel is limited by poor chronological resolution. Material from the lowest part of the earliest phase of the environmental record (BYG1) was dated to the sixth and seventh centuries AD[33], but a first to second century AD[34] date was obtained from the upper part. As a result, evidence for declines in woodland, clearance episodes and the development of a predominantly pastoral landscape cannot be confidently related to patterns of prehistoric settlement or land enclosure. The medieval sequences, with dates that range from the eleventh to fourteenth centuries AD, are more secure and provide valuable information about increasing acidification of soils and periods of local burning, but earlier periods remain frustratingly opaque.

Dating problems are less evident for a second pollen study, carried out on samples taken from peaty deposits on much lower-lying land more than 4km to the south-west of Braich y Gornel (Kenney et al. 2013, Bale et al. 2013), although the lowest pollen assemblage phase was found to be out of

[32] 2970±30 uncalibrated BP, 1285-1055 BC (SUERC-33059)
[33] 1480±30 uncalibrated BP, AD 550-645 (Beta-312792)
[34] 1920±30 uncalibrated BP, AD 25-210 (Beta-360402)

sequence and ignored by the specialist (see *Figure 7.14*, site 12). Two monoliths were taken: one from buried soils below a burnt stone mound, which had one date and four assemblage zones; the other from an area of peat about 50m to the north of the burnt stone mound, which had two dates and six assemblage zones. The pollen preservation was described as excellent, so the very small number of dates obtained from the material is a missed opportunity. Nevertheless, the vegetation history for the area confirms a similar pattern to Graianog. It suggests that the largely wooded landscapes of the fourth millennium BC gradually opened up, with evidence for low levels of disturbance, intermittent episodes of tree clearance and possible grazing. The first decline in oak woodland post-dates the eighteenth to nineteenth centuries BC[35], when increases in grass and sedge (*Poaceae* and *Cyperaceae*) and the appearance of damp-loving herbs (*Rumex* and *Plantago*) suggest sedge-rich grassland. Recovery of tree and shrub species mark a period of less open ground, and it is not until the later first millennium[36] that cereals and species relating to their cultivation appear. Cultivation and grazing appear to have a dramatic impact on oak woodland, which begins its final decline.

The best-dated evidence for plant remains in this area was, like the Rhostryfan boundary cluster, discovered through a development-led excavation (Table 8.1 and Figure 8.1, site 12). In this case, 'corn drying kilns'[37] were found in advance of the construction of a new hospital, Llidiart Yspytty, in Tremadog (Kenney 2006). The site was located on the route of a Roman road that connected the forts at Segontium and Tomen y Mur, within a few kilometres of more than 100 roundhouse sites. Bayesian modelling of radiocarbon dates from cereal grains place the use of the kilns in the second to third centuries AD (2006: 10). Among the six cereals identified in the pollen assemblage, spelt was the most frequently recorded, mirroring patterns found elsewhere in Britain (Akeret 2006). Emmer was the next most frequent cereal, also common to sites of this period. The relatively high occurrence of oat grains was more unusual.

An extensive area of potentially early land division to the north and west of Llidiart Yspytty (Appendix K, transcription map 14) are likely to have been associated with the cultivation of these crops. These 'fields' have relatively low sinuosity boundaries and, like several other groups of ploughed-out boundaries on low-lying land in the study area, their size and greater regularity suggests similarities with extensive areas of small rectangular fields in England and the Netherlands (see chapter 3 for further discussion).

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[35] 3490±30 uncalibrated BP (Beta-348671), 1890-1700 cal. BC.
[36] 2140±30 uncalibrated BP (Beta-348672), 350-50 cal. BC.
[37] The descriptive term 'corn drying' is slightly misleading in this context where they were used to dry other cereals, albeit the use of 'corn' has been used in the literature as a generic term for cereal grains

Harlech and Ardudwy fieldscapes

Good quality palaeoenvironmental evidence is absent from contexts associated with the dense concentrations of early fieldscape features to the south of Harlech. There is potential for localised and detailed sequences to be developed given the waterlogged and well-preserved archaeological remains and areas of intertidal peat found along the coast, but published work on these palaeoenvironmental remains is limited and decades old (Musson 1975, Musson et al. 1989).

As outlined in chapter 5, a crucial area of prehistoric settlement and land enclosure on the uplands of Moel Goedog, further north, has no lidar coverage but excavations in the early 1980s produced palaeoenvironmental sequences from three sampling sites associated with Moel y Gerddi and Erw Wen late prehistoric settlements (Chambers and Price 1988), with further research carried out more recently at Muriau Gwyddelod as part of the wider study of prehistoric field systems in North Wales (Smith et al. 2018).

The results from these studies suggest a pattern of gradual decline in soil quality, following episodes of woodland clearance from the Mesolithic onwards. Chambers and Price (1988) argue that the soil that developed beneath tree cover would have been of good quality and more favourable to agriculture, but declined in quality due to the depletion of humus. A similar trend was identified by Smith et al. (2018) at Muriau Gwyddelod, where excavations revealed buried soil typical of post-glacial woodlands that was deeper and less stony than later soils. The authors are equivocal about the cultivation of cereals, downplaying their significance because of low numbers of identified pollen. However, there is evidence for wheat and barley from all three sites. At Muriau Gwyddelod corn spurrey grains were also identified, and at Erw Wen oat grains suggest the cultivation of this crop.

As with other areas, establishing the chronological relationship between agricultural activities and settlement is difficult. The phasing depends on the comparison of pollen assemblages, peat accumulation rates and a small number of dates from the second or first millennium BC. The assumption is that the roundhouses, enclosures and field boundaries represent a 'well-settled' period, dating from at least the middle of the first millennium BC. Chambers and Price (1988: 100) speculate that population pressure and/or more equable climate encouraged upland settlement and farming, but subsequent climatic and/or soil deterioration resulted in the settlements being abandoned, as the land became suitable only for pasture. They argue that this settlement sequence explains why many features of prehistoric land use still survive (although fragmented by some areas of post-medieval clearance). Johnston has made a detailed field survey and plan of the immediate locality around Muriau Gwyddelod (Smith et al. 2018), but lidar for this area would help establish if fieldscape features survive across a wider area.

Higher altitude studies

A group of palaeoenvironmental studies have been carried out in locations with low concentrations of recorded early boundaries. As a result, they have less relevance to later prehistoric and Roman fieldscapes, particularly where there are no radiocarbon dates (Seddon 1962, Burrows 1974, Tipping 1993) or the dates and pollen sequences are very early (Ince 1983, Ince 1996). The palaeoenvironmental evidence found at Crawcwellt is, however, significant for the study of early land division because there is dated evidence for a small group of boundaries, a settlement and ironworking activity (Crew 1983c, Crew 1989, Crew 1998), as discussed above, and the vegetation history for the site indicates two major periods of change.

The interpretation of the pollen assemblage and charcoal concentrations led the authors to attribute these two episodes to the late Bronze Age and late Iron Age (Chambers and Lageard 1993). Recalibration of the radiocarbon dates revises this chronology, placing the first likely clearance and burning of vegetation after 1520-1120 BC[38] and a possible second episode around AD 130-340[39]. The vegetation history of another ironworking site 15km to the north-east (and just outside the study area) also suggests abrupt declines in woodland cover close to the hillfort at Bryn y Castell (Mighall and Chambers 1995), but here tree clearance dates to between 975-800 BC[40]. As with the sequences identified along the north coast by Woodbridge et al. (2012), local conditions, including human activity, appear to play a critical role in the pattern and timing of vegetation change.

Early fieldscapes and land tenure

The long-term vegetation trends outlined above indicate the steady expansion of pasture, and the evidence for cereal grains from excavated sites, along with broader trends in Britain (Mulville 2008), point to mixed farming practices during the first millennium BC. Making sense of the relationship between people and land is challenging set against this very broad context, where there is relatively little detail about subsistence practices and the way in which they changed over millennia. Interpretation is heavily reliant on inference from a small number of sites and analogy with evidence elsewhere.

[38] 3090±80 uncalibrated BP (B-63855)
[39] 1780±35 uncalibrated BP (GrN-18405)
[40] 2720±50 uncalibrated BP (GrN-17580)

As highlighted in chapter 3, it is also shaped by theoretical perspectives. The close relationship between people and their natural environment does not imply that agricultural change was determined solely by the environment or governed by an ideal of rational economic maximisation. Neither did agricultural intensification necessarily emerge everywhere or develop in response to hierarchical and competitive political networks. Scarcity, exploitation and ownership are not exclusive drivers of change.

If tenure is understood in relational as opposed to territorial terms – or as Wickstead and others (Johnston 2001, Kitchen 2001, Johnston 2005a, Wickstead 2007, Wickstead 2008b, Chadwick 2008a, 2008a), describe it, as part of the constitution of identity - then serious consideration must also be paid to the role land division played in collective and shared access to resources, including those that would be understood today as cosmological, mythic or supernatural. Boundaries are not simply a matter of dividing up and managing space (Paasi 2014). Relational approaches to tenure allow for interpretations that imagine other ways of relating to land, relating to other people and to oneself – that is, other ways of being in the world.

Embracing complexity and uncertainty, implicit in more expansive relational approaches, also exposes the difficulties of working with poorly refined chronologies. The seasonal movement of people and animals would have been an integral part of life for people living in the first millennium BC, yet the way in which these related to the process of land division as it unfolded - its character, timing and relationship to settlement and the cultivation of crops – cannot be understood without new dating. In the light of these challenges, historic traditions of land tenure and studies of small-scale, pastoralist communities provide important sources of inspiration: two contrasting examples are explored below to illustrate their relevance to early enclosure in Snowdonia and help with understanding the processes that led to their creation.

The first example is a lexicography of land tenure for modern West Africa, comprising a glossary of terms from English and French speaking areas (Leonard and Longbottom 2000). As the authors outline, the terms are derived from land law and administrative systems imposed by the British and French colonial governments. These were themselves strongly influenced by different national histories, including the French revolution of 1789 and the English civil wars of the seventeenth century. The differences between the two approaches, particularly the way in which they related to indigenous tenure systems, meant that the authors found it difficult to find clear equivalents between English and French terms. However, they state that ‘if the underlying concepts behind British and French colonial laws are difficult to align, it is even more difficult to interpret and classify indigenous West African tenure concepts using European or Western frames of reference’ (Leonard and Longbottom 2000: 3). This was, as they argue, partly because indigenous concepts were usually based on communal forms of resource management.

In spite of the linguistic and conceptual struggles faced by the authors, almost 200 land tenure terms were listed in the lexicon, providing some illuminating examples of the varied and sophisticated concepts in play in one (admittedly large) geographic area at a single point in time. They include, for example, *droit de hache* (axe rights) and *droit de feu* (fire rights) which arose from clearing, cutting and burning bushland vegetation, with the *agreement of the first occupier* (my emphasis). In the forest, the exercise of these rights was associated with certain plants such as the bush mango, which is one of only a few fallow species to thrive in regrowth forest. Its presence in primary forest is a sign of ancient human use and thus of the past appropriation of land. (Leonard and Longbottom 2000)

Axe and fire rights illustrate the way that certain plants, sequences of land use and commonly understood agreements between individuals or groups have an important bearing on land tenure. While the concept of 'rights' in the case of West Africa has historically specific links with the rejection of feudal land holding and emphasis on absolute individual rights in post-revolution France, the way in which the natural world is bound into tenurial relationships has parallels with the episodes of tree clearance and regeneration that preceded the first enclosure boundaries in Snowdonia.

Other common tenurial relationships identified in many parts of Africa include 'rights of access' which stem from membership of a particular social group. These rights are different from *affectation* (allocation) of land to a family, household or individual, which was neither permanent nor alienable. Similarly, bush-fallow rotation systems (*culture sur jachère*) involve customary relationships between certain communities and the land, entitling farmers to return to fallow land they previously cultivated. The authors developed a concept of derived rights (*droits délégués*) to refer to a range of delegated rights and relationships between one group or individual and another. They exist in many different forms and normally stem from negotiated agreements. Farmland examples are sharecropping, gift, marriage gift, pledges and temporary allocation to strangers. In the case of natural resources, derived rights could include grazing rights to crop residues on farmland, harvesting rights to trees, fodder cutting, grazing, woodcutting, gathering on common land, fishing rights or lifting water from wells (Leonard and Longbottom 2000: 20).

The rich and diverse tenurial relationships found in modern West Africa are, of course, specific to their historic and geographic context, but they have interesting points of contact with the second example explored in this chapter, Gwynfor Pierce-Jones' study of early medieval field systems in North Wales (Jones 1973). This work was based on a group of manuscripts relating to land in

Gwynedd written in Welsh and referred to as *Llyfr Iorwerth* (Book of Iorwerth), all of which, bar one, are thirteenth century in date. Jones argues that the manuscripts give a general impression of long-established mixed farming practices. The Welsh terms suggest that complex rules of patrilineal inheritance were also based on much older customs (Jones 1973: 433). Unlike England, land in North Wales was divided equally among all male heirs, a practice known as *cyfran* (a form of partible inheritance). As with the examples from West Africa, the nuance and detail can be lost in translation: for example, c*yfran*, unlike its English equivalent *gavelkind*, also included special rights for the youngest son to inherit his father's homestead.

Tenurial rights were exercised conditionally on behalf of descendants and freedom to dispose of land was severely restricted by complex customs that were designed to preserve patrilineal control. Jones cites the use of the term *gwely*, which referred to a group of relatives. These kin groups were constituted in different ways depending on context and could be large. For example, payments were made by large groups in lieu of blood feuds. The land of the *gwely*[41] came to be known as a 'resting place' or 'bed', in the 'sense of a permanent stake in the soil' (Jones 1973: 434).

One aspect of tenure discussed by Jones is particularly interesting in the context of early land division: the manuscripts state that tenure was acquired as a result of continued occupation of land over four generations but this right could only be lost after nine generations had elapsed (Jones 1973: 439). Like the farmers of West Africa who returned to fallow land they had previously cultivated, peoples' absence from an area did not necessarily signal its 'abandonment' or sever their relationship with it. Tenurial records also refer to a fourth century dispute about conflicting claims to land tenure, which Jones argues was consistent with the kind that could arise under the nine-generation rule. He suggests that this feature of customary law probably stemmed from late prehistoric (or earlier) traditions because it conflicted with Roman principles, raising issues of such importance that 'recourse was made to the Emperor's court in what seems to have been a test case' (Jones 1973: 440).

Thus, shifting patterns of land use between and across the coastal lowlands and uplands of Snowdonia may have involved not just people and animals moving between grazing areas, but also intermittent and seasonal crop cultivation that would have required people living close by for at least part of the year. This seems most likely for fields at higher elevations. A sixteenth-century reference, cited by Jones, refers to mountain land, described as 'wilde grownd', cultivated for corn only once every 20 years or so, which provided pasture for sheep or young cattle in intervening years (Jones 1973: 444). The assumption that arable crops could not be grown at higher altitudes in

[41] Gwely means 'bed' in modern Welsh.

mountainous areas (cf Smith 2018b: section 6) is mistaken, as indicated by written accounts and by extensive areas of ridge and furrow (Longley 2006, Kenney 2015). Although there are not, as yet, any definitively early examples from North Wales, cereals dating to between 2100 and 1250 cal BC have been found growing at an altitude of 500m on the border between England and Scotland (Halliday 2017).

The cultivation of crops at higher altitudes illustrates the difficulty understanding land tenure in Snowdonia when discussion is so reliant on abstract concepts, rather than specific knowledge of domesticated and wild plants and animals, and their relationship with people. Viewing subsistence in purely economic terms is also and inevitably reductive. Only the slightest clues are left to animate narratives and incorporate perspectives where the supernatural is as present and real as the natural world.

Traces of pre-first millennium BC communities and their final 'resting places' have been invoked to illustrate the importance of the uplands and high mountains as sacred places. Concentrations of third and second millennia funerary monuments above Penmaenmawr and Ardudwy, for example, have obvious ancestral connections, as do the scores of burial cairns located on mountain peaks and summits of the Carneddau, where they are visible from the valleys and lowlands below (Roberts 2007b). Perhaps, like the Norwegian idea of *utmark* employed by Downes and Thomas (2013) to describe the Bronze Age landscape in Orkney, by the first millennium BC the high mountains of northwest Wales had come to be associated with separate and mythical places, visited intermittently by communities herding their stock or tending crops over the summer months.

Concluding comments

This chapter has considered how human and environmental processes explain patterns of early fieldscapes, focusing on subsistence and land tenure practices. It has involved discussion of palaeoenvironmental evidence and how this can be related to locations where this PhD project has identified and mapped higher concentrations of early fieldscape features. It also drew on historic traditions of land tenure and studies of small-scale, pastoralist communities to consider new perspectives that are relevant to early enclosure in northwest Wales.

Subsistence practices are hard to link directly to fieldscape patterns. Although Snowdonia has a long history of palaeoenvironmental research, studies are not evenly distributed across the area. There are large variations in the quality and quantity of dating which, like the roundhouses, boundaries and enclosures, has a big impact on their interpretive value.

The evidence is best for the uplands and upland fringe of the northern Carneddau (north Snowdonia), where recent work on vegetation sequences illustrated the potential to relate them to land division. They showed that woodland habitats were replaced by grasslands between about 1000 BC and AD 1000, with multiple episodes of clearance and regeneration occurring in an area close to upland slopes where dense concentrations of early fieldscapes have been identified during this PhD research. Curved and irregular boundary patterns suggest an incremental construction process that took place over decades or centuries. This is likely to have been episodic in a similar way to the sequence of vegetation clearance and regeneration identified through the palaeoenvironmental work. Tree clearance was more abrupt in areas with early settlement and field boundaries than at higher altitudes, where the decline was more gradual. There is evidence for pastoralism in the first millennium BC, but it is not known if people kept cattle, sheep, goats or horses (or combinations of these). Woodland loss accelerated between the third and first centuries BC in the lowlands, where plant remains indicate that nearby fields, newly discovered through the current research, and visible as low, ploughed-out banks, may have been used to grow spelt wheat, barley, emmer wheat and oats.

Elsewhere the evidence is less good. The lack of palaeoenvironmental evidence is most obvious in the southern part of the study area. Dense concentrations of early fieldscape features mapped as part of this PhD research are found here but not in locations where reliable, securely dated, palaeoenvironmental work has been undertaken. In other areas, problems with identifying first millennium BC and AD phases mean that vegetation histories are of limited value. Occasional well-dated contexts provide high quality information about crops and plants for specific areas.

While this thesis identifies long-term trends for increased woodland clearance, cultivation and pastoralism, the discussion emphasises variation between geographic areas, and the influence of local conditions in the pattern and timing of vegetation change. This chapter argues that interpretations of the fieldscapes should draw on rich and diverse models for tenurial relationships and should employ new language and concepts to understand ways in which land and resources are shared communally. Early medieval Welsh land inheritance laws and customs suggest that mixed farming practices were long established and embedded in complex kinship ties. They also imply that shifting patterns of land use between and across the coastal lowlands and uplands of Snowdonia involved not just people and animals moving between grazing areas, but also intermittent and seasonal crop cultivation.

Field boundaries were caught up in a reflexive relationship with the communities that created them. They emerged out of changing engagements between people, land and the wild and domesticated plants and animals on which their lives depended. In turn, these fieldscapes created new conditions for inhabitation and the creation of identity. The importance of aspect and exposure in their construction, recognised during this PhD project, suggests that further research should focus on exploring these characteristics and their relationship to the development of mixed farming practices. Key questions that should shape this work are identified in the next, concluding chapter, along with a discussion of methodological recommendations and suggestions for specific case studies.

Table 8.1

Radiocarbon dates from principal palaeoenvironmental studies in or close to the study area

Details included for fourth millennium BC dates onwards, calibrated using OxCal 4.4 (24 August 2020) and rounded to nearest 5 years (Ramsey 2009)

Map reference	Site	Description and references	Laboratory code	Radiocarbon age (BP)	Calibrated date (95% confidence)
1	Upper Aber Valley	Targeted palaeoenvironmental study to inform archaeological understanding of land use history, based on pollen and plant macrofossil analysis. Five samples taken from peat deposits. Chronology based on 11 radiocarbon dates. (Woodbridge et al. 2012)	UB-15759	1049±34	AD 900-1030
			UB-15760	2445±34	750-410 BC
			UB-15761	4815±37	3691-3521 BC
			UB-15762	2000±34	90 BC-AD 75
			UB-15763	3976±36	2580-2350 BC
			UB-15764	4123±25	2870-2580 BC
			BETA-246691	830±40	AD 1050-125
			BETA-246692	2140±40	360-50 BC
			BETA-246693	3350±40	1740-1530 BC
			BETA-270954	510±40	AD 1320-1450
			BETA-270955	2330±40	520-215 BC
2	Cors Wern Goch, Aber	Vegetation history based on pollen analysis. Samples from fen deposits. (Hughes and Grant 2005, Hughes and Grant 2006)	Report unavailable		
3	Waun Llanfair	Targeted palaeoenvironmental study to inform archaeological understanding of land use history, based on pollen and plant macrofossil analysis. Three pollen columns and five excavated contexts analysed, including 21 radiocarbon dates of which 7 dated to the second or first millennium BC. (Caseldine 2003a, Caseldine 2005, Caseldine et al. 2007, Caseldine 2007, Caseldine et al. 2017)	Beta-235899	3310±40	1730-1500 BC
			Beta-186679	3490±40	1925-1690 BC
			Beta-239194	2110±40	350 BC-AD 5
			Beta-211080	3190±50	1605-1305 BC
			Beta-235898	2870±60	1255-900 BC
			SUERC-27556	3660±35	2140-1935 BC
			Beta-224978	3230±40	1610-1420 BC
4	Llyn Cororion	Vegetation history based on pollen, charcoal and loss on ignition (LOI) profile analysis. Samples from peat deposits and chronology based on 11 radiocarbon dates. (Watkins 1990, Watkins et al. 2007)	SRR-3467	780±60	AD 1050-1390
			SRR-3468	1585±65	AD 335-610
			SRR-3469	4985±65	3945-3655 BC

5	Parc Bryn Cegin	Palaeoenvironmental work carried out as part of development-led excavation with 5 dated contexts with palaeoenvironmental remains. (Kenney 2008a, Schmidl et al. 2008, Marshall et al. 2008)	Bayesian modelling of 116 radiocarbon dates		
6	Melynllyn Tarn	Vegetation history based on diatom and pollen analysis. (Walker 1978, Harkness 1981: 301)	SRR-634 SRR-635 SRR-636 SRR-637 SRR-638	2060±60 1630±90 2670±120 3420±110 4760±90	350 BC-AD 70 AD 220-620 1120-430 BC 2020-1460 BC 3705-3360 BC
7	Ysgol yr Hendre, Caernarfon	Palaeoenvironmental assessment of samples for plant macrofossil and charcoal survival, from development-led excavation. (Kenney and Parry 2012, Kenney and Parry 2013)	Bayesian modelling of 24 radiocarbon dates		
8	Cwm Cilio	Targeted palaeoenvironmental study of soil and peat deposits to inform archaeological understanding of land use. Two radiocarbon dates obtained from two charcoal samples. Four radiocarbon samples from peat deposit pollen core. (Smith et al. 2018)	SUERC-33062 SUERC-33063 Beta-312794 Beta-360404 Beta-312793 Beta-360403	3505±30 6135±30 800±30 1940±30 910±30 550±30	1920-1745 BC 5210-4990 BC AD 1180-1280 AD 10-205 AD 1040-1215 AD 1320-1435
9	Graianog	Targeted palaeoenvironmental study to inform archaeological understanding of land use history related to excavated site. Based on pollen analysis. 5 radiocarbon dates. (Botterill and Chambers 1998)	CAR-67 CAR-68 CAR-72 CAR-69 CAR-70	745±40 1225±40 1130±45 1035±45 2305±40	AD 1210-1380 AD 680-890 AD 775-995 AD 890-1150 470-205 BC
10	Cefn Graianog Quarry	Palaeoenvironmental assessment of 41 samples for plant macrofossil and charcoal survival, from development-led excavation. (McKenna 2016)	No published radiocarbon dates		

11	Braich y Gornel	Targeted palaeoenvironmental study to inform archaeological understanding of land use history. 4 radiocarbon dates from buried soil contexts. 4 radiocarbon dates from pollen core. (Smith et al. 2018)	SUERC-33059 Beta-312792 Beta-360402 Beta-312791 Beta-337425 Beta-312792 Beta-360402 Beta-312791 Beta-337425	2970±30 1480±30 1920±30 980±30 620±30 1480±30 1920±30 980±30 620±30	1285-1055 BC AD 550-645 AD 25-210 AD 995-1160 AD 1295-1400 AD 550-645 AD 25-210 AD 995-1160 AD 1295-1400
12	Llidiart Ysptytty, Tremadog	Palaeoenvironmental work for development-led excavation. 5 radiocarbon dates from charred plant remains. (Akeret 2006)	Beta-205125 Beta-205126 Beta-205127 Beta-205128 Beta-186679	1840±40 1820±40 1830±40 1770±40 3490±60	AD 75-315 AD 85-325 AD 80-320 AD 135-380 1965-1670 BC
13	Pentrefelin	Palaeoenvironmental work for development-led excavation. 4 radiocarbon dates from two pollen monoliths. (Bale et al. 2013, Kenney et al. 2013)	Beta-348671 Beta-348672 Beta-348673 Beta-348674	3490±30 2140±30 3020±30 1720±30	1890-1700 BC 350-50 BC 1390-1130 BC AD 250-410
14	Llyn Dwythwch	Vegetation history based on pollen analysis. (Seddon 1962)	No radiocarbon dates		
15	Nant Ffrancon	Vegetation history based on pollen analysis. (Seddon 1962)	No radiocarbon dates		
		Vegetation and environmental history based on analysis of plant macrofossils. (Burrows 1974)	No radiocarbon dates		
		Vegetation history based on pollen analysis. (Hibbert and Switsur 1976)	20 radiocarbon dates with a span between 10,000-4000 BP		

16	Llyn Peris	Vegetation history based on pollen and macrofossil analysis. Samples from lake sediment. Three radiocarbon dates, two with dates older than the eighth millennium BC. (Tinsley and Derbyshire 1976)	Birm-556	1750±100	AD 65-535
17	Llyn Padarn	Vegetation history based on pollen analysis. Samples from peat deposits. (Harkness 1981: 301-302)	SRR-406 SRR-407 SRR-408	1470±80 3580±80 7070±80	AD 405-610 2190-1700 BC 6075-5760 BC
18	Cwm Idwal	Vegetation history based on pollen analysis. (Tipping 1993)	No radiocarbon dates		
19, 20	Cwm Cywion and Llyn Llydaw	Vegetation history based on pollen analysis. (Ince 1983)	5 radiocarbon dates with a span between 10,000-8000 BP		
21	Clogwyngarreg	Vegetation history based on pollen analysis. (Ince 1996)	4 radiocarbon dates with a span between 14,000-10,000 BP		
22	Muriau Gwyddelod	Targeted palaeoenvironmental study to inform archaeological understanding of land use history. 2 radiocarbon dates from buried soil contexts. (Smith et al. 2018)	SUERC-33060 SUERC-33060	4525±30 8155±30	3360-3100 BC 7315-7055 BC
23	Moel y Gerddi	Palaeoenvironmental study to inform archaeological understanding of roundhouse. 7 radiocarbon dates from wood charcoal samples. (Kelly 1988b: 136, Chambers and Price 1988)	CAR-397 CAR-398 CAR-525 CAR-526 CAR-527 CAR-528 CAR-529	4590±80 2350±70 4760±70 2250±70 4540±70 4030±80 2290±70	3620-3030 BC 755-205 BC 3645-3370 BC 455-55 BC 3510-3015 BC 2875-2345 BC 725-160 BC
24	Moel y Gerddi Valley Mire	Targeted palaeoenvironmental study to inform archaeological understanding of land use history of two upland late prehistoric sites. Based on pollen analysis. 8 radiocarbon dates, 2 of which are second millennium or later in date. (Chambers and Price 1988)	CAR-660 CAR-641	1665±60 3715±70	AD 240-540 2340-1910 BC

25	Erw Wen	Palaeoenvironmental study to inform archaeological understanding of roundhouse. 3 radiocarbon dates from wood charcoal samples. (Kelly 1988b: 136, Chambers and Price 1988)	CAR-530 CAR-531 CAR-532	2410±60 2660±60 2470±70	755-395 BC 980-595 BC 775-410 BC
26	Llanaber	Analysis of wooden trackway. (Musson 1975, Musson et al. 1989)	HAR-1015 HAR-1216 HAR-1217 HAR-1218 HAR-741 HAR-742 HAR-743	1760±90 1130±70 580±70 2730±220 840±70 890±80 850±70	AD 60-530 AD 710-1025 AD 1285-1440 1445-390 BC AD 1040-1275 AD 1015-1270 AD 1035-1270
27	Crawcwellt	Targeted palaeoenvironmental study to inform archaeological understanding of land use history related to research excavation of iron-working settlement. Based on pollen analysis and estimates of charcoal concentrations. 4 radiocarbon dates. (Chambers and Lageard 1993)	GrN-18405 B-63855 B-63856 GrN-18406	1780±35 3090±80 4660±110 5470±55	AD 130-340 1520-1120 BC 3655-3040 BC 4450-4180 BC
28	Llwyn Du	Targeted palaeobotanical study to inform archaeological understanding of land use history related to research excavation of iron-working settlement. Based on pollen analysis from 5 sample sites. (Middleton 1998)	No code	2060±70	350 BC-AD 75
29	Bryn y Castell	Targeted palaeoenvironmental study to inform archaeological understanding of land use history related to research excavation of hillfort. Based on pollen analysis. 15 radiocarbon dates. (Mighall and Chambers 1989, Mighall and Chambers 1995, Mighall and Chambers 1997, Crew and Mighall 2013)	HAR-6105 HAR-6106 HAR-6107 HAR-6108 HAR-6109 GrN-17579 GrN-17580 GrN-17581 GrN-17582 GrN-17583 GrN-17584	750±70 1610±70 2170±70 3860±70 5080±90 2480±35 2720±50 4715±40 1655±50 2690±70 4610±55	AD 1055-1395 AD 255-600 385-52 BC 2560-2135 BC 4045-3660 BC 775-430 BC 975-800 BC 3635-3375 BC AD 255-535 1020-765 BC 3625-3105 BC

			GrN-17633	2060±80	355 BC-AD 120
			GrN-17578	4010±70	2860-2305 BC
			GrN-17534	2920±80	1385-910 BC
30	Llyn Morwynion	Targeted palaeoenvironmental study to inform archaeological understanding of land use history. 7 radiocarbon dates. 3 sample sites. (Caseldine et al. 2001)	Beta-136977	290±60	AD 1450-1940
			Beta-136978	520± 60	AD 1295-1465
			Beta-136979	1510±60	AD 425-645
			Beta-136980	2930±70	1375-930 BC
			Beta-158560	3830±60	2470-2065 BC
			Beta-136981	3820±70	2470-2040 BC
			Beta-158561	1590±60	AD 340-600

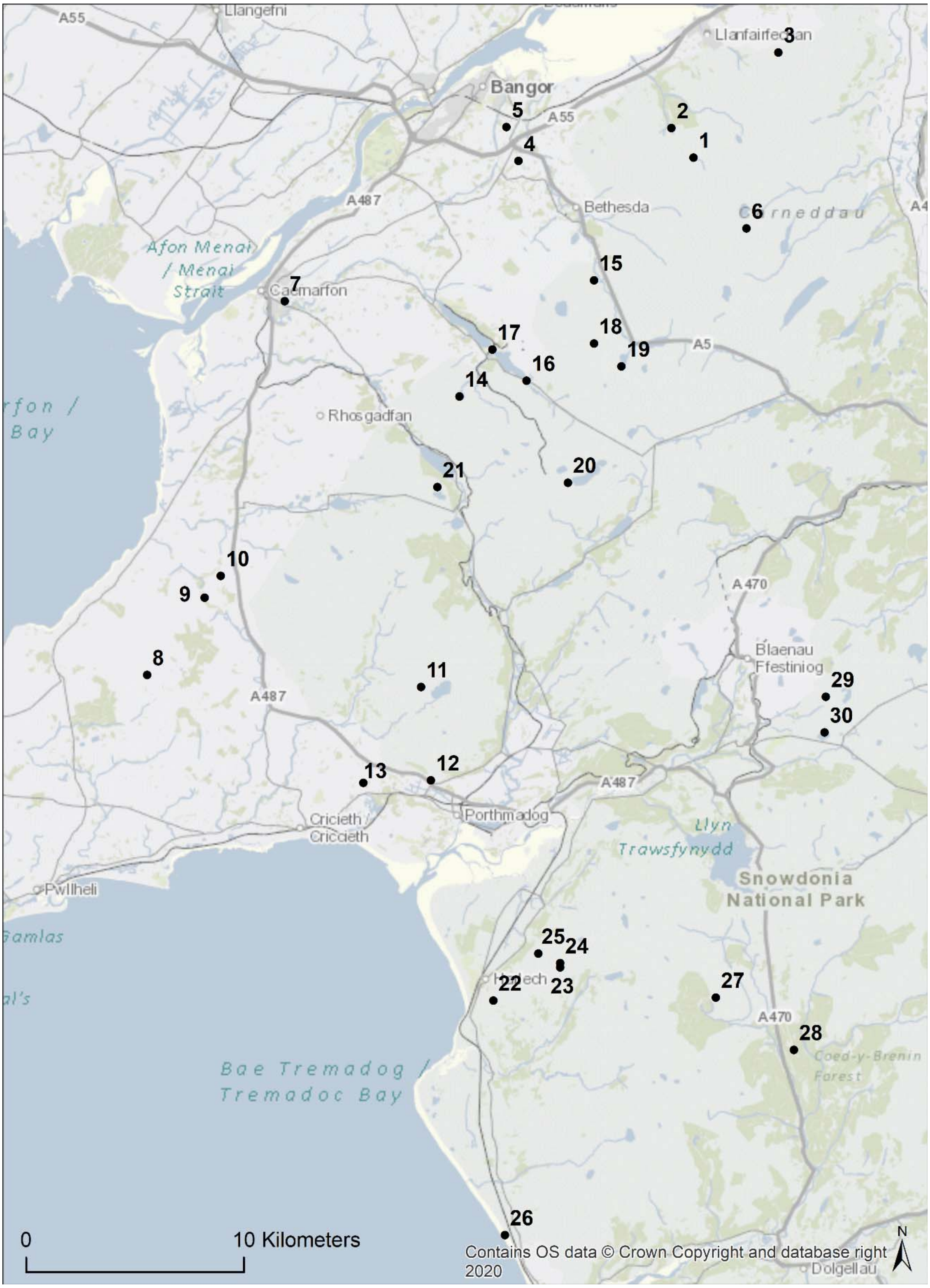

Figure 8.1
Palaeoenvironmental studies

(see overleaf for key)

Map reference	Site name
1	Upper Aber Valley
2	Cors Wern Goch, Aber National Nature Reserve
3	Waun Llanfair
4	Llyn Cororion
5	Parc Bryn Cegin, Llandygai
6	Melynllyn Tarn
7	Ysgol yr Hendre, Caernarfon
8	Cwm Cilio
9	Graianog
10	Cefn Graianog Quarry
11	Braich y Gornel
12	Tremadog
13	Pentrefelin
14	Llyn Dwythwch
15	Nant Ffrancon
16	Llyn Peris
17	Llyn Padarn
18	Cwm Cywion
19	Cwm Idwal
20	Llyn Lyddaw
21	Clogwyngarreg
22	Muriau Gwyddelod
23	Moel y Gerddi
24	Moel y Gerddi Valley Mire
25	Erw Wen
26	Llanaber
27	Crawcwellt
28	Llwyn Du
29	Bryn y Castell
30	Llyn Morwynion

Chapter 9
Conclusions

Early enclosure in Snowdonia

While the first published investigation of prehistoric roundhouses in Snowdonia dates to the 1860s (Owen 1866), it was not until the mid-twentieth century that small, sub-rectangular terraced fields and 'wandering' walls were identified by archaeologists as 'field systems' associated with settlements (RCAHMW 1956). Since then, aerial mapping and field survey have increased the number of boundaries, enclosures and features such as cairns associated with the process of early land division. However, the known distribution of early fieldscapes was fragmentary across upland areas. In the last decade, preliminary examination of lidar imagery highlighted the potential for this new source of evidence to reveal far more extensive remains. This thesis contributes to the realisation of this potential and the opportunity to understand the processes that led to their creation and survival.

Research context: epistemic issues

Framing this study in terms of fieldscapes rather than field systems was a simple way to acknowledge the relationship between different landscape elements and broaden the study's historiographic scope, as outlined in chapter 2. Synthesising material from a wide range of sources highlighted the focus on 'hut' morphology and dominance of typological approaches to both settlement and field systems. This emphasis is a product of culture-historical models and their influence on excavation and survey strategies, which have been principally concerned with investigating roundhouse settlements. Although the idea (still evident in mid-twentieth century studies) that different 'hut types' might be associated with distinct groups of people has disappeared, other elements associated with this perspective persist. The most influential example is a social evolutionary model that characterises settlement types and field systems as evidence for the natural progress from semi-nomadic herding to settled farming.

Epistemic issues were discussed in more detail in chapter 3, as part of a review outlining the wider research context for the study of late prehistoric and Roman fieldscapes. This highlighted the continued dominance of culture-historical accounts in prehistoric studies and archaeological practice more generally in North Wales, and the way that this has left it adrift from wider cultural and intellectual movements of the last half century. Failure to critically engage with the nature and construction of knowledge has led to a reductive research environment for excavation and survey. Comparison with England suggests that these issues are compounded by structural differences that are a product of lower levels of economic activity together with differences in state approaches to the historic environment (heritage is a devolved responsibility in Wales).

A recent assessment of scientific dates for field systems across England, for example, was based on samples from predominantly development-led contexts (Johnston and May 2016). It showed that large-scale land division began in the early centuries of the second millennium BC and was an ongoing, though geographically discontinuous process. There is no equivalent review of development-led (or other) sites in Wales. This is, in part, because there is less development, but perhaps also because, unlike England, there are no regional scientific advisors and consequently specialist techniques are applied less often and less consistently. England has also benefited from the publication of a major study of the English landscape from 1500 BC to AD 1086 (Gosden et al. In Press-a), based on the synthesis of multiple, large datasets including Local Authority HERs. There is currently no equivalent study in Wales considering long-term landscape patterns and trajectories in a theoretically engaged or collaborative way.

While variations in archaeological practice have an important influence on discoveries in this research area, there is evidence from across northwest Europe for the appearance of widespread land divisions in the second and first millennium BC. As with their development in England, the process followed different trajectories in different places, with some boundaries continuing in use into the first millennium AD. The breadth and variety of European studies provide a rich comparative dataset for northwest Wales, illustrating the way in which theoretical perspectives shape different research traditions, from economic and political models, to approaches that explore cosmological, mythic or symbolic associations. Two key developments were highlighted in relation to the fieldscapes of Snowdonia: the importance of exploring relational as opposed to territorial approaches to land tenure, and the use of methods and interpretive frameworks that consider early land division as a long-term phenomenon.

Data collection: digitising from lidar models and developing new geodatabase schema

The 1m resolution lidar for northwest Wales was collected on behalf of the Environment Agency Wales[42] for mainly flood-defence purposes. It is therefore concentrated along the coast and river valleys. In spite of this, there is good, albeit partial, coverage for much of the study area. Initial inspection of hillshade lidar models indicated the survival of archaeological remains across a larger area than anticipated. The use of the Relief Visualisation Toolbox (RVT) to generate multiple lidar visualisations (Kokalj et al. 2016) from digital terrain (DTM) and digital surface models (DSM), hugely increased the visibility and recognition of archaeological features and improved digitising accuracy.

[42] The agency is now incorporated within Natural Resources Wales, part of the Welsh Government

Other sources of information, such as aerial photographs, infra-red photography, historic maps, modern Ordnance Survey maps, previous survey data and point-data records held nationally and locally, were also consulted, using a fully integrated GIS (ESRI's ArcGIS).

An area of almost 142,000 hectares was analysed, an increase of two thirds on the initial study area. Accurate spatial extents were created for almost 14,000 individual archaeological features, most of which were earthwork banks or mounds. Simple local relief models (SLRM) created using the RVT were particularly good at revealing ploughed-out boundaries in lower lying areas where no evidence for enclosure had been previously recognised. Open-positive lidar models showed smaller or detailed sites such as roundhouses, routeways and paths most clearly, often in areas of known early fields. The increase in newly identified features was more than 80% for boundaries, clearance cairns and areas of ridge and furrow. Overall, more than four fifths of all digitised features had not been previously recorded.

Although the dataset was much larger than anticipated, the importance of structuring and documenting information was recognised in advance of digitisation. The geodatabase was carefully designed to support analysis: attribute data could be captured quickly and accurately using controlled terminology and auto population of fields where appropriate. There was no duplication of information held elsewhere. The methodology, outlined in chapter 4, was developed following detailed analysis of the regional Historic Environment Records (HER) and a critical review of the National Monument Programme (NMP) in England. The incremental and often ad hoc way in which these records have developed explain many of their geodatabase quirks and weaknesses.

In contrast to previous datasets, the geodatabase schema for the early fieldscape dataset was structured to be fully compliant with UK and international data standards, including information on the extent, quality, spatial and temporal schema and distribution of digital geographic data. Adhering to these standards ensures that information is easy to use by people who are unfamiliar with the research or topic. Where possible polygonal records have been cross-referenced with regional and national numbering systems, including references to scheduled monuments, so that concordance between the different datasets is not too resource intensive.

One important aspect of the methodology was a significant departure from previous database structures: two related but separate datasets were created, each with multiple, detailed attribute fields. The separation emphasised the difference between the surviving *form* of archaeological remains (the *transcription* dataset) and their interpretation as an archaeological *monument* (the *research categorisation* dataset). Although these concepts are commonly used in historic environment records, dividing them in this way was a novel approach. By increasing the granularity of spatial attributes, the accuracy and analytical potential of the data was improved. Experimenting with this approach was a valuable exercise given the limited integration of polygonal data in conventional databases, but the approach would have been too time-consuming without the use of drop-down menus, controlled terminology and automated workflows. The use of a large digitising tablet also increased accuracy and speed.

Working with two datasets was well-suited to fieldwork because observations could be linked to individual features with accurately defined spatial extents (the transcription dataset). Creating a separate workflow to categorise monuments highlighted the reliance on morphology and typology for identifying and dating features, expanding the scope to revise and refine current chronological approaches. Beyond identifying features as 'early' because they did not appear on later nineteenth-century Ordnance Survey maps, most monuments were dated by analogy or association with other sites or features, usually roundhouses. Nationally agreed terminology was used wherever possible, but many monuments could only be attributed to a 'late prehistoric to early medieval' period, roughly identified as spanning 1000 BC and AD 1000. It was particularly difficult to distinguish ancient from modern 'mounds', and half were not categorised as archaeological 'monuments' because of uncertainty over their interpretation and date.

A series of methodological recommendations for future work are made in chapter 4. These include issues relating to metadata and the collection of accurate and consistent information, suggestions to improve efficiency, problems with particular landforms and features, and the need to document workflows.

Geostatistical analysis: developing new quantitative methods

The large sample size, rich metadata and consistency of the early fieldscapes dataset created a unique opportunity to develop new techniques to help understand early land division. Elsewhere researchers have either worked with smaller datasets (Wickstead 2007, Brown 2016) or, in the case of the large and synthetic EngLaId study (Green and Gosden In Press), with information from multiple sources. Data selection for geospatial analysis has generally been based on their recognition as coaxial, brickwork or aggregate field systems, which *a priori* established them as coherent entities. The boundaries identified in Snowdonia were not always as easy to define because of variable preservation levels and their irregular form. In the light of this, the analysis initially set out to identify the location of well-preserved groups of boundaries, roundhouses and enclosures, using preservation levels and coherence as proxies for early fieldscape 'integrity'. Two new methods were developed for assessing the relative height of features (preservation) and their density (coherence):

1. A method for assessing Relative Feature Height (RFH) was developed using the composite 1m lidar data to create a DEM for measuring height values within and adjacent to features. The approach measured the difference in elevation between the minimum and maximum value in a moving 3m by 3m cell neighbourhood. Zonal statistics were calculated for each digitised feature using the transcription as the input feature dataset.

2. A method for assessing coherence was adapted from a Grouping Analysis geospatial approach originally employed in other disciplinary contexts. The grouping analysis tool (ArcGIS 10.6) makes use of unsupervised learning methods to identify natural groupings that maximise within-group similarity and between-group differences. A novel approach was developed to define ‘seeds’ by identifying peak points in a kernel density surface and using them in the grouping analysis.

Well-preserved earthworks survived as more prominent landscape features and were recorded as having a higher RFH; less well-preserved or ephemeral remains had lower RFHs. The density of boundaries provided a guide to fieldscape coherence, and comparison with the concentrations of circular enclosures indicated a correlation between the two. Unsurprisingly, dense, well-preserved boundaries – that is, those with higher integrity - were more likely to have been recognised during fieldwork and recorded in regional or national records. However, analysis also showed that even well-preserved features often had heavily ploughed out sections which had not been previously identified or recorded.

Fieldscape integrity proved a good measure for preservation and coherence, confirming the location of previously recorded field systems along the northern coastal uplands of the Carneddau, and further south, between Harlech and Barmouth. It also led to the recognition of many smaller clusters along the northern and western fringes of the study area, particularly on lower-lying ground. These groupings were used to assess the comparative distribution of other geospatial metrics developed to explore the character of fieldscapes.

Two key characteristics were identified as having the greatest potential for further analysis: (1) topographic setting, exploring the relationship between boundary orientation, aspect and slope and (2) field shape, distinguishing coaxial, aggregate (less regularly perpendicular field systems) and curvilinear enclosure patterns. To assist with this analysis, a semi-automated method was developed to create a centre polyline for all digitised features. The degree to which the fieldscapes of Snowdonia had straight or curved boundaries was measured by comparing line length with the shortest distance between its start and end point. The methodology follows similar approaches used to assess the sinuosity of rivers and is referred to here as the sinuosity index. A second innovation was to take multiple measurements along boundaries to assess their alignment, and to compare this detailed dataset to the geospatial values extracted from the 1m resolution DEM for aspect, slope, and elevation.

Geostatistical analysis of the results revealed important correlations and distributions:

- More than two thirds of boundaries are located on south, south-west or west facing slopes. Just under a third are on north or northwest facing slopes. Only a tiny proportion (4%) are on north-east, east or south-east facing slopes.
- The correlation between alignment and aspect showed a weak negative association; that is, there was a slight tendency for boundaries to be aligned perpendicular to aspect.
- The distribution of alignment and aspect values shows a strong tendency for boundaries to respect aspect.
- The distribution pattern for boundary orientations shows that they are clustered within a very tight range (34 degrees) across all slopes: almost 80% are aligned perpendicular to the prevailing wind direction.
- This strong relationship between boundary alignment and aspect can be observed for the whole dataset and for local clusters of high integrity features.
- There is a significant weak correlation between boundary alignment and elevation, and a weak negative association between sinuosity and elevation. Both measures indicate that sinuosity increased very slightly with elevation.
- There is no correlation between alignment and slope.

These describe a strong and distinctive pattern of early land division with important connections to the natural environment: enclosure took place on slopes which maximised sunshine and where the varied shape and location of boundaries reduced the impact of prevailing winds. Their irregular form demonstrates that boundaries were built by people who paid close attention to the effects of climate on the microtopography of different areas. It suggests that they were built incrementally over years, decades or possibly centuries rather than in a single episode.

Early fieldscapes: qualitative approaches

The quantitative results presented in chapters 5 and 6 demonstrated how detailed data collection and analysis helped to identify new and unexpected patterns for early land enclosure, with important implications for understanding the social and political context in which they emerged. Chapters 7 and 8 incorporated these findings with qualitative evidence for settlement, boundaries and subsistence practices, including excavation records and palaeoenvironmental evidence, published synthetic studies of roundhouse settlements in northwest Wales, and previous transcription from aerial photographs.

The evidence from excavations and the work carried out for this thesis, including new survey work, have identified considerable variations in boundary construction and re-use. Examples include a probable late first millennium BC hazel hedge, low stony and earthen banks, terraces, stone-faced boundaries, and the incorporation of stony cairns. There is no evidence that boundaries were particularly high or that they always fully enclosed parcels of land. They may, instead, have formed part of a broad set of practices which involved herding and hefting stock between different areas.

Roundhouse settlements were considered in detail because less than a fifth (17%) of regional point-data records were identified on lidar models, making them unsuitable for geospatial analysis. Only a fraction of the known examples (<5%) have been excavated, and of these a handful have radiocarbon dates which, with one exception, are effectively useless by modern standards. As a result, beyond attributing roundhouses to a broad span between 1000 BC and AD 1000, it was not possible to identify more specific chronological patterns.

This has important implications for the interpretation of fieldscapes, which are predominantly dated by physical association with roundhouses or analogy based on morphological similarity. Because it is not possible to compare when and for how long roundhouses were in use, it is also not possible to draw direct or causal links between changing settlement permanence and nucleation, or between agricultural intensification and settlement nucleation. Traditional economic approaches that neatly align land division with the process of agricultural intensification and increased sedentism are dependent on these assumptions.

The focus of the analysis presented in this thesis was on relational approaches to land tenure and the process of early land division. An argument is made in chapter 8 for interpretations to draw on richer and more diverse models for tenurial relationships, and the use of new language and concepts to understand ways in which land and resources are shared communally. These include early medieval Welsh land inheritance laws and customs which suggest that mixed farming practices were long established and embedded in complex kinship ties.

Field boundaries were caught up in a reflexive relationship with the communities that created them. They emerged out of changing engagements between people, land and the wild and domesticated plants and animals on which their lives depended. In turn, these fieldscapes created new conditions for inhabitation and the creation of identity.

Directions for future research

The discussion in this section is structured around four key questions that refine and amplify the themes identified in chapter 1. They include recommendations for the use of scientific techniques and the potential for future work.

(1) When did boundaries emerge as permanent features of the landscape and how long did they remain in use?

Detailed and widespread dating is the top research priority for understanding the emergence of boundaries and their subsequent use and re-use. Recently published work from the Netherlands (Arnoldussen 2018) and Cornwall (Vervust et al. 2020) indicates that Optically Stimulated Luminescence Profiling and Dating (OSL-PD) is the most accurate, practical and cost-effective methodology available. The application of the technique in Cornwall involved the excavation of small, hand-dug trenches across features, and analysis of sediment stratigraphies on site to identify key horizons for dating. Additional sediment samples were taken for laboratory analysis. By obtaining multiple dates, a detailed chronological picture can be pieced together for the original construction and subsequent use of a single feature. The authors demonstrate that the technique can be used to understand the origins and evolution of field boundaries, terraces and cultivation ridges, recommending that future applications are combined with a full range of soil-science techniques.

The results from this thesis provide the foundations for developing a dating programme in Snowdonia. An iterative approach to boundary selection is recommended, given the early stage of development for the technique. OSL-PD was not effective on three of the five selected boundaries from Bosigran (Netherlands) because excavation did not reveal their complete construction histories (Vervust et al. 2020). For the two successfully dated boundaries, one confirmed a suspected Bronze Age date but the other indicated a Middle Iron Age date, which was later than anticipated.

The samples taken in Cornwall set out to test the methodology on different boundary 'types', but in the light of their results, a better sampling strategy may be one that is concentrated on small geographic areas. Establishing localised patterns would focus attention on long chronologies rather than simply seeking to identify very early land division. Comparison between dated fieldscapes in different parts of Snowdonia would allow the emergence of land division to be assessed at a regional scale and would help rebalance an excessive focus towards periodised approaches. Comparisons could also be made between fieldscapes that survive at different altitudes and in varied topographic contexts.

(2) What is the full extent of surviving early boundaries in northwest Wales?

While the research carried out during this thesis expanded the known distribution of early boundaries, there are two significant gaps within the existing spatial datasets that means their full extent has not been recorded. The first is the result of lidar quality and its partial land coverage, the second is a product of the digitising strategy.

Lidar quality and coverage

As outlined in chapter 5, there are still large areas of northwest Wales without lidar coverage. There is also low feature recognition in areas where lidar cannot penetrate dense vegetation, such as steep wooded valleys, dense conifer forest and dense gorse. More intensive investigation of north and east facing slopes is particularly important given the conclusions of this research which suggest these slopes were deliberately avoided.

When/if lidar data becomes available it should be processed using the Relief Visualisation Toolbox (RVT), or similar GIS software, to create a range of visualisations. More detailed lidar models, such as 0.25m resolution data recently collected (2020) for the Carneddau Landscape Partnership Scheme[43], offer the potential to refine spatial extents for known features. In some cases, better resolution models can pick up new features.

The extensive survival of heavily ploughed-out boundaries in low-lying areas suggests that analysis should be extended to the whole of northwest Wales, to include the Llŷn Peninsula, Conwy Valley and Anglesey. The results of geophysical survey from Cwm Cilio also suggest that this survey technique could work well in some contexts (Smith et al. 2018). It would be valuable to carry out a comparative study between high resolution lidar and geophysical survey.

The key areas where lidar coverage is missing or ineffective, but early fieldscape features are known or likely to survive are:

- Maen y Bardd settlement and field system[44] on the slopes below Tal y Fan (figure 5.21, transcription map 3).
- A large strip of land between Llanrug and Waunfawr, where the dense survival of features below 240m on slopes to the north and south, strongly suggests survival on similar terrain (transcription map 5).

[43] https://www.snowdonia.gov.wales/looking-after/carneddau-partnership
[44] NPRN 15147, PRN 4691, Scheduled Monument CN157

- Lower slopes on the west and north sides of Moel y Ci and Moel Rhiwen, where terraces, lynchets and settlement evidence has been recognised across a wide area (figure 5.22, transcription map 6).
- Caeronwy settlement and field system[45] on the slopes to the north of Nantlle (figure 5.23) transcription map 10).
- Gwernoer and Glangors field systems[46] on the slopes to the south of Nantlle, including enclosures with evidence for ridge and furrow cultivation and clearance cairns (figure 5.24, transcription map 10).
- Early fields[47] and areas of ridge and furrow cultivation[48] recognised on the north and west facing slopes of Blwch Mawr, east of Clynnog Fawr (figure 5.25, transcription map 13).
- Area to the north of Penmorfa, containing ridge and furrow[49], and remains of medieval long houses[50] (Kenney 2015), terraces and roundhouses[51] thought to be prehistoric in date (figure 5.26, transcription map 14).
- Field system[52] and medieval long houses[53], prehistoric roundhouses[54] and settlement[55] on slopes above Llanfihangel-y-pennant, Dolbenmaen (figure 5.28, transcription map 14).
- The slopes of Moel Goedog, above Harlech, where extensive and well-preserved early fields and settlements at Muriau Gwyddelod[56], with further remains surviving to the east including roundhouse settlements[57], ridge and furrow[58], terracing[59], enclosures and cairns (figure 5.27, transcription map 17).
- An extensive area on the uplands above Llanaber, where multiple fieldscape features continue onto higher ground (figure 5.29, transcription map 19).

Digitising strategy

The second problem with establishing the full extent of surviving early boundaries is less straightforward to address: the methodology developed as part of this research excluded

[45] PRN 7986, Scheduled Monument CN179
[46] PRN 6314, PRN 7859, NPRN 308978
[47] PRN 12922, PRN 13176, PRN 14515, PRN 61559
[48] PRN 875, PRN 61946
[49] PRN 59885
[50] PRN 183, PRN 6726
[51] PRN 167, PRN 1335, NPRN 301026, Scheduled Monuments CN237 and CN239
[52] PRN 59870
[53] PRN 174, PRN 2361/NPRN 15067, PRN 6753
[54] PRN 173, PRN 175/NPRN 275746, PRN 176, NPRN 309182, PRN 178
[55] PRN 177/NPRN 309181, Scheduled Monument CN313
[56] PRN 2900, Scheduled Monument ME010
[57] PRN 1053, Scheduled Monument ME098; PRN 6171 Scheduled Monument ME120; PRN 29255
[58] PRN 30440
[59] PRN 1046

boundaries shown on late nineteenth-century Ordnance Survey maps because in the absence of independent dating evidence or scope for an extensive programme of assessment visits, it was not possible to develop consistent criteria for their inclusion.

It seems certain that many later nineteenth-century field systems incorporated long-lived and earlier boundaries, but the difficulty is identifying which ones. Small, irregular fields that survive close to clusters of boundaries that do not appear on historic maps are good candidates, as are those where more pronounced earthwork remains are visible on lidar models. However, while field size, clustering and good earthwork survival are useful proxies, in the absence of better chronological understanding of land division, they are not diagnostic of an early date.

This specific problem can only be addressed by incorporating examples of boundaries that were still extant in the later nineteenth century in the OSL-PD dating programme outlined above, with the aim of developing better criteria for their inclusion in the early fieldscape dataset. Field survey work is also required to assess surviving remains, including ground truthing the geospatial results for Relative Feature Height (RFH) and spatial extent, and the compilation of boundary records with detailed information about their construction and character. Provided high quality attribute data is created for these additions, expanding and refining the dataset in this way will increase the potential for new geospatial and geostatistical analysis.

(3) How did late prehistoric land division relate to settlement patterns?

As outlined in chapter 7, it is not possible to compare when and for how long settlements were occupied, abandoned and re-used, because, with one exception at Rhiwgoch (Kenney 2013), the handful of radiocarbon dated sites in northwest Wales have coarse and/or unreliable chronologies. For obvious reasons, this makes it very difficult to relate them to early boundaries and the process of land division. While roundhouses, settlement enclosures and field boundaries can form coherent groups, implying synchronous use, excavation has demonstrated that many houses were rebuilt close to or overlying earlier sites and there are often complex sequences of boundary realignments and abandonment. As with field boundaries, establishing accurate settlement chronologies is the most important research priority. OSL-PD and radiocarbon dating techniques should be considered on all excavations, with Bayesian modelling used wherever possible to improve chronological resolution.

In addition to chronological difficulties, most known roundhouse settlements have regional point data records rather than polygonal records because they are difficult to identify on lidar models or are in areas without lidar coverage. There are several different databases with relevant information about these sites, including the Roundhouse Database (Ghey 2007), George Smith's Hut Group

Database (unpublished), regional HER and national records. However, cross-referencing these records is difficult and they are time-consuming to incorporate into geospatial analysis. Creating attribute-rich, polygonal datasets that combine these information sources is, consequently, a priority. This would allow more detailed assessment of settlement distribution not just in relation to other fieldscape features but also for metrics developed for boundary analysis, such as RFH, aspect and alignment.

Some of the same issues identified for roundhouse settlements - very coarse or absent dating and location outside areas with lidar coverage – apply to hillforts. There are fifty known examples in the study area but almost all are dated by analogy. They are central to the discussion of the relationship between people and land in analysis by Smith (2018) and Waddington (2013), but a surprisingly low number of sites have evidence for boundaries, enclosures or settlements within or adjacent to them. Waddington (2013: 82) makes a connection between the location of hillforts and the distribution of 'relict fields' in areas with more productive brown earth soils, and Smith (2018: section 7) sees their distribution as indicative of territorial areas and the control of important routes. The chronological relationship between the emergence of land division and fortified hilltop locations is clearly crucially important, but it shares the same chronological challenges faced in relating field division to roundhouse settlement.

More generally, improvements to the collection, organisation and dissemination of data will increase the potential to explore the spatial and temporal development of land division and settlements. The size of the datasets and their geographic extent create excellent opportunities for sophisticated geospatial analysis, but it means individuals and organisations focusing resources on the mundane and unglamorous business of record management. Data collection strategies have traditionally concentrated on ascribing sites to discrete archaeological and historical periods. Combined with relatively simple GIS software and limited processing power, there have been few incentives for creating finer-grained and polygonised datasets, despite excellent mechanisms for developing incremental datasets through regional and national record collection. The results of the early fieldscape research show that simple methodological advances enhance the value and analytical potential of datasets.

The methodologies developed as part of this research provide the tools for reassessing RFH, feature density, boundary sinuosity, boundary alignment and their relationship to aspect, slope and elevation. Although these techniques required powerful computing capacity, the results demonstrate the value of more ambitious analytical approaches. Sharing expertise will allow their application to different and enhanced datasets, including reanalysis of the early fieldscapes dataset if lidar coverage and transcription is expanded into the areas identified above. Advice about designing geodatabase schema and workflows, including statistical analysis, also needs to be documented and disseminated more widely. For example, the analysis of boundary sinuosity, alignment and aspect required polyline data after the original transcription was complete. A semi-automated approach was developed using the polygonal dataset to avoid further hand digitisation; however, it would have been quicker and more accurate to have automated the creation of polylines during the digitisation process rather than after it had finished.

(4) How do patterns of land division and settlement relate to subsistence strategies?

Subsistence strategies, like land division and settlement patterns, are not well understood. They are heavily dependent on the study of pollen and macrofossils because faunal remains rarely survive in the area's predominantly acidic soils. Sediment cores have been taken from lake and peat contexts but their distribution across the study area is uneven and there are insufficient dates for pollen assemblage phases. The results from more recent studies along the north coast (Hughes and Grant 2005, Watkins et al. 2007, Woodbridge et al. 2012, Caseldine et al. 2017) indicate good potential for developing detailed vegetation histories. There are suitable sampling locations in lake deposits and peat deposits, both of which are found across the study area; the coverage for peat as a proportion of total land area is not particularly high (7.3%[60]) compared to the UK (Artz et al. 2019), but its wider distribution across both the uplands and lower-lying land is useful from a sampling perspective.

Like the proposals to focus dating on small geographic areas, it is recommended that studies are based on establishing long-term trends for several localised vegetation histories. Particular attention should be paid to the relationship between initial forest clearance, episodes of regeneration and the presence of wild and domesticated plants. Priority should be given to the southern part of the study area because there are no palaeoenvironmental studies associated with the dense concentrations of boundary and settlement features found there. Adopting an altitudinal transect approach for small areas would allow a critical review of sampling approaches, and comparison with the study by Woodbridge et al. (2012) of the upper Aber Valley. It is possible to assess the location of potential sampling sites in peat deposits because of detailed mapping by Natural Resources Wales (NRW). Preliminary analysis using this dataset suggests that an area of peat immediately north of Craig y Ddinas hillfort[61] and close to the fieldscape features at Ardudwy may be a good candidate for sampling. Identifying suitable lake deposits will require further fieldwork.

[60] Peat covers 10,327 hectares of the study area, which has a total area of 1,419 square kilometres; calculations based on Natural Resources Wales (NRW) Unified peat layer
[61] PRN 1107, Scheduled Ancient Monument ME020

Case studies

Several recommendations made in the section above involve targeted study of small geographic areas. The following case studies have been selected as candidates for this research, as outlined below.

- *Case study 1: Cors y Gedol, Ardudwy*

  This is an area where a dense concentration of high sinuosity features has been identified. It has been selected as a case study because (1) it is depicted on an early estate map of 1770 and therefore has early documentary evidence for land use, making it suitable for further boundary analysis, and (2) it has potential high quality peat sampling sites close to both low-lying and upland contexts, which would make the area suitable for an altitudinal transect sampling approach for a palaeoenvironmental study.

- *Case study 2: Cochwillan, north of Llanllechid*

  This is an area with an unusual concentration of circular enclosures. Six are located within a few hundred metres of one another on the mid-slopes approximately 1.5km to the west (downslope) of the scheduled remains at Llanllechid[62]. The enclosures are similar in size, roughly 35-40m in diameter, and are associated with fragmentary evidence for boundaries. Three enclosures contain what appear to be the remains of stone roundhouses and two are scheduled monuments[63]. This area is included in the new 0.25m resolution lidar coverage for the Carneddau massif (north Snowdonia) and there is therefore the opportunity to compare it with the 1m resolution data: the higher resolution lidar models may reveal new information about the features. Comparison between this area and other scheduled remains nearby in Llanllechid may reveal information about effect of more intensive agricultural use.

- *Case study 3: Pentir*

  This area includes the probable route of a Roman road overlying (or possibly underlying) a group of roughly rectangular fields that had disappeared by the late nineteenth century but were still shown, in part, on the Tithe map of 1840. The case study offers an opportunity to assess the route of the road and its relationship to field division. Four areas of peat are located immediately adjacent to at least one of the boundaries in the group, providing a potential comparative set of sampling locations for palaeoenvironmental work. The

[62] Scheduled Monument CN121
[63] PRN 294, Scheduled Monument CN176; PRN 295, Scheduled Monument CN056

relatively low sinuosity of the boundaries could also be compared in greater detail to other low sinuosity boundary clusters.

- *Case study 4: Graianog Environs*

  This is an area with a dense concentration of late prehistoric and Romano-British early fieldscape features, and a long history of excavation and survey undertaken in advance of gravel extraction. Transcription from lidar models confirmed the survival of four unexcavated probable early roundhouse settlements within a 1km radius of Graianog Quarry. There is evidence for early boundaries surviving adjacent or close to three of them[64], and a third massively built enclosure and roundhouse[65] to the south of the hillfort at Foel Uchaf may be situated in an area of terraced fields. There is excellent potential for survey work, geophysical survey and targeted excavation.

Threat and conservation issues

This thesis has not set out to explore the threats to fieldscape features or the implications of new findings on their conservation. However, in the context of outlining future directions for research, some brief observations and recommendations are outlined below. The departure of the United Kingdom from the European Union has created huge uncertainty about the future of the uplands and Snowdonia faces potentially radical agricultural change.

The principal protection for fieldscapes is their designation as scheduled monuments. Snowdonia has a higher proportion of scheduled monuments by land area compared to the rest of Wales: scheduled monuments occupy about 0.35% of the total land area in Snowdonia compared to 0.30% of the total land area of Wales[66] and in the study area, the bias was more pronounced (0.54% of total land area is scheduled)[67]. Consequently, it could be argued that protection of archaeological remains compares favourably to other parts of Wales.

Of the 411 scheduled monuments in the study area, 80% protect prehistoric sites or features that include site types which are common to early fieldscapes such as ‘enclosed hut circles’, ‘enclosures’ ‘hut circle settlement’, ‘unenclosed hut circle’ or ‘field systems’. Some of the scheduled areas are

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[64] PRN 3999, PRN 118, PRN 121

[65] PRN 193

[66] 376 scheduled monuments covering a total of 746 hectares in the Snowdonia National Park area (2,139 square kilometres total land area), 4186 scheduled monuments covering 6,309 hectares in Wales (total land area 20,735 square kilometres)

[67] 413 scheduled monuments covering a total of 767 hectares in the study area (1,419 square kilometres total land area), 4186 scheduled monuments covering 6,309 hectares in Wales (total land area 20,735 square kilometres)

large: 27 are greater than 4 hectares, of which 16 are greater than 10 hectares and three more than 40 hectares. Despite this, less than 10% of upstanding early fieldscape features are protected by scheduled monument designation[68] and this proportion is significantly less if the spatial coverage of the field systems is taken into account. The key point is that only a small percentage of recognised features are protected by law.

Analysis of Relative Feature Height (RFH) in chapter 6 demonstrated that features within scheduled areas were consistently and significantly better preserved than those outside designated areas. The working assumption that this is largely due to lower levels of ploughing and less intensive land-use needs to be explored in greater detail. Analysis could include the impact of different variables such as site type, land-use (for example using land cover data), the date when a site was scheduled (that is, how long it has been protected by designation) and altitude. Comparison with early fieldscape features that survive in areas designated as Sites of Special Scientific Interest (SSSIs), where there are also consent mechanisms to control land-use, indicates similar RFH values[69] although the number of features is far lower[70].

It is more difficult to evaluate the influence of the Registered Landscapes of Outstanding and of Special Interest in Wales Historic Landscape (Welsh Assembly Government 2007), because more than half the study area is covered by one of thirteen designated areas and their role in historic environment conservation is only advisory. However, large lowland areas with concentrations of previously unrecognised boundaries are not included in the registered landscapes and conversely, important areas of known early fieldscapes, such as Moel Goedog, are located in registered areas but do not have lidar coverage.

In addition to assessing threat and conservation issues for fieldscape features identified in this research, there are implications if the recommendation to expand analysis to extant and nineteenth-century boundaries (as laid out earlier in this chapter) is adopted, and some prove to have early origins. The removal of boundaries has been affected by changes to legal and subsidy frameworks over the last fifty years and the risks they face in the immediate future are uncertain given the imminent end to the European Union (EU) Common Agricultural Policy (CAP) in Britain. A study of stone walls in the Brecon Beacons noted that until the introduction of the CAP Single Payment Scheme (SPS) to England and Wales in 2003, walls were unprotected and many miles removed for field enlargement or simply for selling off valuable stone (Fry 2009: v). The main threats were theft

[68] Calculation is based on spatial extent (polygonal area) of transcribed features that fall within scheduled areas (38 hectares), compared to those that do not (323 hectares).
[69] Mean *mean* RFH of 0.05m and mean *maximum* RFH of 0.23m
[70] Spatial extent of transcribed features (16.9 hectares) in SSSIs (362 square kilometres) is 0.05%.

of stone from derelict walls in open countryside and the sale of stone close to major conurbations such as the Pennines and the Brecon Beacons, where extensive lengths of wall were robbed for re-use in the gardens and renovations of houses (Fry 2009: 15).

It is not clear how farm subsidy payments will be affected by the departure of the United Kingdom from the European Union, but historical precedents suggest that direct and indirect impacts of major change will be high. Reduced or abolished headage payments for sheep, for example, may result in major declines in their numbers and an increase in upland gorse, bracken, heather and trees as grazing levels decrease; the indirect impact of these changes would be greater vegetation coverage over extensive and ephemeral earthwork remains, including early boundaries and settlement sites. Reduced visibility is known to increase the risk of inadvertent damage. More direct impacts are likely if there are increased incentives for intensifying production methods; this could result in larger areas of land being ploughed, with the attendant damage to earthworks and further removal of boundaries. Predicted climate change may also drive the expansion of more intensive farming methods, because of warmer mean temperatures and longer growing seasons. Improved pasture and increasing cultivation have recently been identified as risks for the uplands in Wales (The Historic Environment Group Climate Change Subgroup 2020: 26).

Given the potential impact of these changes, the conservation of archaeological remains through their designation as scheduled monuments is unlikely to be suitable for the extensive and often ephemeral early fieldscape remains. Engagement with a wider policy environment is therefore essential. Potential threats need to be balanced with the opportunities that change can bring, and there is a strong case for prioritising research into the conservation of early fieldscapes so that recommendations can be developed to influence the development of government subsidy and land management schemes, particularly elements that involve payment for 'environmental goods'. Alongside this more strategic focus, almost all scheduled areas for sites that date to the late prehistoric and Roman periods need to be reassessed; scheduled monument boundaries often appear to be drawn in the wrong place, with significant and well-preserved early fieldscape elements present or extending beyond existing protected areas.

Concluding comments

The early settlements and fields visible on lidar models of Snowdonia have a beauty and coherence that is very seductive. The ability to 'see' a vast landscape in one snapshot prompts the viewer to consider land division as a phenomenon at a regional scale and, in that sense, this perspective is incredibly valuable: the boundaries, roundhouses, enclosures and cairns appear intuitively to be connected to one another. While these patterns have been central to the research for this thesis, understanding the processes that led to their creation and survival has involved moving beyond simply identifying and mapping features to consider how new geostatistical methods could be developed to help with analysis. The difficulty, as with land division elsewhere in Europe, is developing reliable and refined chronologies. The working assumption that boundaries initially appear in northwest Wales in the first millennium BC is based on their association with roundhouse settlements, but there are frustratingly few clues to the pace and character of this process and its subsequent development into the first millennium AD.

The principal achievement of the research presented in this thesis has been to develop an approach that is able to capture and analyse the complexity of fieldscapes, including uncertainty about their date and interpretation. This involved using quantitative and qualitative methods to build a detailed geodatabase with the potential for sophisticated geospatial and geostatistical analysis.

Several innovative techniques were developed to assess the geographical distribution and preservation of features, to analyse their form, cohesion and relationship with the landscape. Although it was not possible to model time depth, the strong correlation between boundary alignment and ground aspect demonstrated a significant, underlying pattern of land division: enclosure was bound up with detailed knowledge of and responses to microtopography, and the ways in which land was shaped by the weather. Sunnier slopes were selected, and earthwork and stone banks helped to reduce the impact of prevailing winds. Across the mountainous terrain of Snowdonia, this created a network of curvilinear and irregular boundaries. On lower-lying slopes and flatter land, sinuosity was less pronounced, but boundary alignment appears to have responded similarly to ecological conditions.

These preliminary findings illustrate the power of new techniques and detailed data collection strategies to breathe new life into narratives about early land division. Rather than interpreting boundary and settlement 'types' as evidence for the natural evolution of farming, it focused on understanding the human and environmental processes that led to the creation of early fieldscapes. This approach is not an appeal to an idealised empirical bedrock, but to 'dense tangles of empirical and conceptual argument that are mutually reinforcing and mutually constraining' (Wylie 2017: 34).

The doctoral research has drawn on historic traditions of land tenure and studies of small-scale, pastoralist communities to consider new perspectives and approaches to early enclosure. It has explored the materiality of boundaries (their physical remains) to help understand their temporality, linking variations in construction techniques to different levels and types of labour, stability and change.

Understanding the precise character and timing of land division requires more extensive and detailed dating. The geodatabase developed as part of this research can be mined or enhanced to incorporate new information that will help to refine the date and use of individual features so that temporal and spatial patterns can be reassessed. This work will hopefully include improvements to dating using OSL-PD and Bayesian modelling of radiocarbon dates, and transcription of features from lidar models in areas previously without coverage and at higher resolution (sub 1m). The geospatial and geostatistical tools developed during this research can be reapplied to these larger and richer datasets.

Sustained collaboration involving the use and re-use of detailed datasets is essential for future research. Exploring long-term extensive patterns of land use is complex, involving incremental acquisition and synthesis of new information from different disciplinary contexts: it means recognising and seizing opportunities that arise in development-led contexts as well as designing new research programmes. Above all, it requires working with expansive models of social change that embrace interpretations sensitive to other ways of relating to land, relating to other people and to oneself – that is, other ways of being in the world.

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Appendices

Appendix A: Summary of research in northwest Wales, relevant to fieldscapes

DECADE	*Date*	*Scope of Research*	*Reference*	*Site Names (None Specified for Multiple Sites)*	*Strengths / Weaknesses / Relevance*
PRE-1900	1860s	Excavation	Owen (1866), Owen (1867), Owen (1872)	Llanllechid	Influential First published excavation and typological classification of roundhouses
	1862, 1868	Excavation of several roundhouses and enclosure	Stanley (1867), (1868, 1869, 1870)	Ty Mawr, Holyhead, Anglesey	Although not in the main study area, the work is relevant to broader history of roundhouse excavation
	1860s	Excavation	Prichard (1867)	Bryn Ddiol, Llaneugrad, Anglesey	Although not in the main study area, the work is relevant to broader history of roundhouse excavation
1900s		Excavation of roundhouses	Baring-Gould and Burnard (1904), Hughes (1907)	Tre’r Ceiri hillfort, Llanaelhaearn	Largest and best-preserved hillfort in northwest Wales, with good survey and evidence from excavation
	Early 1900s	Survey and excavation of hillfort in advance of quarrying; 89 stone roundhouses recorded, 35 excavated	Hughes (1912), Hughes (1915), Hughes (1922), Hughes (1923)	Braich y Dinas hillfort, Penmaenmawr	Very large hillfort, destroyed through quarrying

	Early 1900s	Excavation of hillfort	Lowe (1912: 75-84)	Caer Lleion, Conwy Mountain	
		Excavation of enclosed settlement	Baynes (1908)	Din Lligwy, Anglesey	
1910s		Inventory	RCAHMW (1914)		First of the RCAHMW surveys, part IV Denbigh
	1919	Excavation	Crawford (1920)	Hengwm, Merionethshire	
1920s		Inventory; included site descriptions and some simple site plans	RCAHMW (1921)		RCAHMW survey, Merionethshire
	1920s	Section excavated through boundaries of hillfort; central roundhouse excavated	Hughes and Lowe (1925)	Bryngaer Dinas hillfort, Llanfairfechan	
	1920s	Continued excavation	Hughes (1922), Hughes (1923), Hughes and Lowe (1925)	Braich y Dinas, Penmaenmawr	

		Excavation of hut circle	(Hughes 1928)	Llanystumdwy, Gwynedd	
	1922, 1923	Excavation of roundhouse	Williams (1922), Williams (1923b), Williams (1923a)	Rhostryfan	
1930s		Excavation	Baynes (1930b), Baynes (1930a)	Bry Ddiol, Llaneugrad and Din Lligwy	
		Excavation	O'Neil (1936), O'Neil (1940)	Caerau, Clynnog	
		Excavation	Phillips (1932a), Phillips (1932c), Phillips (1932b), Phillips (1934)	Penmon and Pant-y-Saer, Anglesey	
		Inventory of Anglesey	RCAHMW (1937)		
	1938, 1939	Survey and review of 'hut circles'	Gresham (1941)		

1940s	1944	Synthetic review of 'hut circles'	Hemp and Gresham (1944)		Peer review in Antiquity (Crawford 1952) article and later (Gresham 1972) Continued typological classification
	1945	*Caernarfonshire Excavation Committee* founded	(Gresham 1972: 51-52)		Intention to oversee programme to excavate different types of hut sites
	1949	Excavation of roundhouse	Bersu and Griffiths (1949)	Llwyn-du Bach, Penygroes	
1950s	1951	Overview of 'huts and their associated field systems'	Griffiths (1951a), Griffiths (1951b)		
	1953	Excavation	Gresham (1972)	Cwm Ystradllyn	Excavation by Bersu
	1950s	Further excavation of hillfort; sections cut through boundaries and some roundhouses	Griffiths and Hogg (1956)	Caer Lleion, Conwy Mountain	
	1950s	Excavations	Griffiths (1958), Griffiths (1959)	Penmaenmawr Rhiwlas, Badafon, Cors-y-gedol and Caer'r mynydd	

	Late 1950s	Excavation of enclosed settlement in advance of gravel extraction	Hogg (1969)	Cefn Graianog, Clynnog, Dwyfor	First of excavations at this gravel extraction site; excavations continue today.
	1937-1953	Inventory; includes review of previous work, original survey and original survey plans	RCAHMW (1956)	East area of Caernarfonshire	Included 11 survey plans depicting field systems
	1959	Synthetic study, based on paper presented at British Summer School of Archaeology held in Bangor	Hogg (1965)	Multiple sites	Illustrated dominance of hillforts in discussion of settlement
1960s	1938-1962	Inventory; includes review of previous work, original survey and original survey plans	RCAHMW (1960), (1964)	Central and west area of Caernarfonshire	Included a total of 13 survey plans (10 and 3 respectively) depicting field systems
	1966, 1969	Discussion of 'native' rural settlement	Hogg (1966), Hogg (1969)	Cefn Graianog, Clynnog, Dwyfor	
	1967	Field survey, synthesis and analysis	Bowen and Gresham (1967: 176-224)	Multiple sites	Context for understanding is shift to permanent settlement and agriculture
	1966-67	Rescue excavations carried out during construction of industrial estate	Musson (1970), Houlder (1967), Houlder (1968), Lynch and Musson (2004)	Llandygai industrial estate, Bangor, Gwynedd	Settlement excavated following discovery of Neolithic and Early Bronze Age ceremonial complex. No radiocarbon for roundhouses themselves. Probably later prehistoric, but upper layers lost. Multiple house construction phases identified.

	1968 (-1998)	Long programme of community excavation	Crew (1998)	Crawcwellt, east of the Rhinogydd, Gwynedd	First season of long series of annual excavations, begun in the 1960s, at late prehistoric iron-working settlement site.
1970s	early 1970s	General archaeological survey of region	Bowen (1974)	Meirionnydd, Gwynedd	
	1971-1974	Excavation of enclosed group of roundhouses	Fairburn (1999)	Cae Metta, Llanddeiniolen	
	1972	Synthesis of material on prehistoric Wales	Lynch and Burgess (1972)		
	1973	Synthetic review of prehistoric agricultural economy	Feachem (1973)		First detailed consideration of agricultural economy Deterministic, based on general data rather than specific models for northwest Wales Pages 333-334 discussion of Wales and figure of Penmaenmawr Contention that climate change led to reduction in crops grown in highlands, greater stock
	1974, 1977	Synthetic review of roundhouses	Smith (1974), (1977, 1985b)		Synthesis in the light of new material, particularly better dating evidence. Further analysis of round huts, through the use of numerical taxonomic approaches
	1976	Rescue excavation along route of gas pipeline	Kelly (1979)	Pentir to Llanfairpwll, Gwynedd	

	1978, 1979	Excavation	Crew (1978), Crew (1979)	Cyfannedd Fawr, Arthog (Llanegryn)	Possible stone field boundary found below the peat
	1977-79	Excavation of settlement site before destruction by gravel quarrying	Goodburn (1978), Mason et al. (1998)	The Graianog Ridge / Cefn Graianog, Clynnog, Gwynedd	Second phase of excavation at this gravel extraction site revealed three separate phases of settlement.
	1971-1981	*Ardudwy Survey*; included general survey and excavation at two settlement sites	Kelly (1982a), Kelly (1988b), Smith (2011: 21-22)	Moel y Gerddi and Erw-wen, Harlech	Interpretation of dates, in particular pits in the centre of the enclosure dated to Neolithic. Probably best quality excavation, reasonably extensive; several radiocarbon dates Very important excavation, influential for establishing first millennial BC date for roundhouses
1980s	1979-1985	Excavation of hillfort	Crew (1980), Crew (1983a), Crew (1983b), Crew (1984), Crew (1985), Crew (1987), Crew (1998)	Bryn y Castell, Ffestiniog	
	1978-1987	Excavation; consideration of wider settlement context in synthesis	Smith (1984), Smith (1985a), Smith (1986), Smith (1980), Smith (1987)	Tŷ Mawr, Holyhead, Anglesey	Radiocarbon dates and extensive excavation; dates need re-examining
	1980-81	Excavation of two circular enclosures (continued from 1970s)	Kelly (1988b)	Moel y Gerddi, Harlech; Erw Wen, Harlech	Interpretation of dates, in particular pits in the centre of the enclosure dated to Neolithic 4030 ± 80 BP (CAR—528). Probably best quality excavation, reasonably extensive; several radiocarbon dates Very important excavation, influential for establishing first millennial BC date for roundhouses
	1985	Review of early upland settlement	Smith (1985b)		Detailed consideration of upland field systems association with roundhouses: ‘stone-walled enclosures, terraces, and cairnfields’, reference to radiocarbon dating

	1985	Consideration of early agricultural landscapes	Briggs (1985)		Number of other academic, synthetic papers published in collected volume (Spratt and Burgess 1985)
	1985, 1987, 1988	Excavation of settlement site in advance of gravel extraction	Kelly (1988a), Kelly (1998)	Cefn Graenog, Clynnog, Gwynedd	Third phase of excavation in advance of gravel extraction revealed further evidence for Iron Age settlement, with better quality radiocarbon dating results
	1989	Gazetteer of excavated roundhouses	Johnstone (1989)	Multiple sites	
	1985-1987	Excavation	Longley (1998)	Bryn Eryr, Anglesey	Significant site, although not in core study area, 31 radiocarbon dates and detailed environmental study by Astrid Caseldine (Longley 1998: 252-261)
1990s	1990	Environmental overview	Caseldine (1990)		First major overview of palaeoenvironmental evidence in Wales
	1990	Synthesis by Kelly following work in the 1980s	Kelly (1990b)		See review by Manning (1992)
	1990, 1991	Discovery by aerial survey in 1989, followed by two excavation seasons, which included geophysical survey	Kelly (1990a), Kelly (1991), Ward and Smith (2001)	Meyllteryn Uchaf, Botwnnog	Only partially written up by Kelly; final report completed by Smith a decade later. One radiocarbon date from charcoal sample

	1991, 1992	Excavation of roundhouse, in advance of Felinheli by-pass	Longley et al. (1998)	Bush Farm, Felinheli, Gwynedd	Early enclosure wall identified during the excavations
	1990s	Excavation to evaluate route of A55 road scheme, Anglesey	Kenney and Smith (2001), Smith and Kenney (2001), Kenney (2001a), Smith (2004b)	Melin y Plas, Bryngwran, Anglesey	
	1992	Excavation and survey at site damaged by farming 'clearance'	Gruffydd (1992)	Section through lynchet, no dating evidence	No attempt to take samples, or consider scientific approaches to archaeology, in particular soil micromorphology. One of very few examples of an excavated lynchet.
	1993, 1995	Published synthetic overview	Lynch (1993), Lynch (1995)		Continued influence of culture-historical approaches to prehistory in Wales.
	1996	Published synthetic study of aerial survey of Snowdonia	Crew and Musson (1996)	Ty Tan Dderwen, Bala Bryn y Castell hillfort, Cwm Caseg, Llanllechid Crawcwellt, Trawfynydd Hafod Gelyn, Aber Cors Uchaf, Tal y Bont Bwlch Ffordd, Trawsfynydd Ffridd Bod y Fuddai, Trawsfynydd	Colour photographs, emphasis on landscape and aerial perspectives. Discussion of 'wandering walls and terraced fields'.
	1997	Published synthesis of early medieval settlement	Longley (1997)	Multiple sites	Understanding of early medieval and medieval landscape and settlement crucial for understanding landscape development

	1994-1998	Thematic survey of hut circles	Smith (1999a)	Multiple sites	Restricted to roundhouses – need to check, but recall focus on houses Grey literature report, helped inform subsequent publication by Smith in *Archaeologia Cambrensis* (2001)
	1997-1998	Topographic survey of 6 hut circle settlements at risk	Smith (1999c)	Moel y Gerddi, Llanfair Penbodlas, Buan; Cororion, Tregarth; Ffridd Ddu, Tranwsfynydd; Llyn Morwynion, Ffestiniog; Caerfadog Uchaf, Dolbenmaen	Included some survey and observations of field boundaries.
	1997-1998	Field survey and palaeoenvironmental sampling	Caseldine et al. (2001)	Llyn Morwynion, Ffestiniog	Dating and detailed palaeoenvironmental study Lake-side context and burial of one roundhouse below peat make this a site with very high potential
	1997-1998	Scoping study and survey deserted rural settlement	Jones (1997) Jones and Thompson (1998)	Caernarfonshire	Relevant because many of the sites identified were roundhouses; acknowledgement of similar problems with chronology
	1968-1998	Continued excavation and published summary of excavations (1968-1990s)	Crew (1998)	Crawcwellt, east of the Rhinogydd, Gwynedd	Published summary of a couple of decades of excavation
	1999	Excavations along the route of the new A55	Maynard et al. (1999), Cuttler (2012), Roberts et al. (2004)	Cefn Cwmwd, Rhostrehwfa, Anglesey	

2000s	2000	New academic syntheses of Roman and early medieval Wales	Davies (2000), Davies and Arnold (2000), Lynch and Davies (2000)		
	2000	Academic synthesis of material for prehistoric Wales	Lynch et al. (2000)		
	2001	Synthetic review of roundhouses in the light of the hut circle survey work carried out in the mid-1990s	Smith (2001)	Multiple roundhouse settlements	Comprehensive and thorough; focused on scheduling potential of extant remains not understanding; site based not focused on landscape; some information on context
	2001	Archaeological watching brief in advance of gravel extraction	Kenney (2001b)	Cefn Graianog, Clynnog, Gwynedd	Revealed evidence of field boundaries of possible prehistoric date
	2001-2002	Pilot studies of field boundaries	Roberts and Thompson (2001), Roberts and Thompson (2002)		
	2001, 2002	Ardudwy Early Landscapes project	Johnston and Roberts (2001), Johnston and Roberts (2002)	Short field seasons 2001 and 2002 to assess the effectiveness of different methodologies	Not fully published; first explicitly theoretical approach to material
	2003	Published research framework	Longley (2003)	Multiple sites	First published period-based research framework for northwest Wales

	2003	Published research framework	Caseldine (2003b)	Multiple sites	First published research framework for palaeoenvironmental archaeology in Wales
	2004	Survey, geophysical survey and targeted excavation of defended enclosures	Smith (2005), Smith (2006), Smith and Hopewell (2007b), Hopewell et al. (2008), Smith (2008)	Multiple sites	Incidental but sometimes very useful references to field boundaries
	2002-2008	Study of Roman forts environs	Hopewell (2003), Hopewell (2005), Hopewell (2006), Hopewell (2008)	Multiple sites	Aimed to identify the extent and character of the archaeological remains in and around the Roman forts of Gwynedd, to assess their condition and present management regime and to recommend management options.
	2003-2008	Programme of upland survey work of land above 240m	Scott Jones (2003), Laws and Brooks (2004), Schofield (2004), Schofield (2005), Schofield (2006), Roseveare (2008), Laws and Brooks (2007), Schofield (2008a), Schofield (2008b)	Multiple sites	Many field boundaries, roundhouses and settlements identified through survey programme; first systematic mapping of polygonal features.
	2005	Analysis of garden plots	Johnston (2005b)	Cwm Ffrydlas and Mynydd Du	Broad consideration of garden plots in the Bronze Age of northern and western Britain, which includes specific reference to examples in northwest Wales.
	2004-2007	Creation of database and analysis of all radiocarbon-dated roundhouse settlement	Ghey et al. (2007), Ghey (2007), Ghey et al. (2008)	Multiple sites	

	2008	Methodological critique and survey of upland field system	Johnston (2008b)	Cwm Ffrydlas upland field system	
	2004-2007	Compilation of a database for all radiocarbon dates in Wales	Burrow and Williams (2008)	Multiple sites	High quality synthesis and large number of information fields for all radiocarbon dates in Wales (to 2007), georeferenced, in a database format.
	2006-2007	Excavation	Caseldine et al. (2017)	Waun Llanfair, Llanfairfechan	
	2008	Re-excavation of roundhouse within hillfort	Smith (2009)	Caer Lleion, Conwy Mountain	
		Excavation in advance of gravel extraction		Cefn Graianog, Clynnog, Gwynedd	Fourth major phase of excavation at extensive gravel extraction site, involved evaluation and watching briefs
	2008-2009	Excavation in advance of the construction of a waste water treatment works	Berks and Evans (2008), Cooke et al. (2010), Davidson (2011), Kenney (2012b), Kenney (2013)	Rhiwgoch, Harlech	Settlement evidence closely associated with other remains, field boundaries etc. First use of Bayesian analysis for radiocarbon dating. Discussion of field boundary (Kenney 2013: 227)
	2009-2010	Excavation in advance of new development site		Tŷ Mawr, Holyhead	Vast 45-hectare development plot included the excavation of landscape features such as field boundaries, the best-preserved example of a roundhouse settlement in northwest Wales, and proposals for an extensive radiocarbon dating programme; unfortunately, the project has not been written up because of difficulties funding the post-excavation phase.

2010s	2010- present	Excavation of enclosure by Bangor University staff and students	Waddington (2010b), Waddington (2010a), Waddington and Karl (2010), Karl and Waddington (2011), Waddington and Karl (2015a), Waddington and Karl (2015b), Waddington and Karl (2016), Karl et al. (2016b), Karl et al. (2016a)	Meillionydd, Penllŷn	
	2011-2015	Continued upland survey of land above 240m	Hayman and Horton (2011), Railton (2011), Kenney (2014), Hall and Sambrook (2015)	Multiple sites	
	2010-2011	*North West Wales Early Fields Project*; scoping study included geophysical survey, limited trench excavation, palaeoenvironmental analysis, survey and synthesis	Smith (2011), Smith et al. (2018)	Three case studies: Cwm Cilio, Llanaelhaearn; Braich y Gornel, Cwm Ystradllyn; Muriau Gwyddelod, Harlech	
	2013	Synthetic review of settlement based on roundhouse database	Waddington (2013)	Multiple sites	Comprehensive review of roundhouse settlement sites, including gazetteer, site biographies, cross-references and overview.
	2015	Study of medieval field systems	Kenney (2015)	Multiple sites	

	2010, 2017	Research framework for palaeoenvironmental data	Caseldine (2010c), Caseldine (2010a), Caseldine (2010b), Bale et al. (2017)	Multiple sites	
	2010, 2014, 2016	Updated research framework for the Bronze Age and Iron Age	Gale (2016), Gale (2010), Gale (2014)	Multiple sites	
	2010, 2016	Updated research framework for Roman studies	Davies (2016), Davies (2010b), Davies (2010a)	Multiple sites	

Appendix B: List of landscape scale field survey by RCAHMW (1937-1962)

*Survey areas based on GIS calculations not original reporting

Table B1

RCAHMW (1956) Caernarvonshire, Volume 1: East

Survey name	Reference	Summary of features depicted on survey plan (use of original terms)	Survey area (hectares)*
Early fields and dwellings, Ffridd Ddu, Aber	Figure 26	Survey plan depicts extensive area of occupation, including the identification of old and modern walls.	182
Early remains north of Hafod Gelyn, Aber	Figure 27	Survey plan depicts extensive system of early fields, ancient walls, and other early remains.	85
Pant-y-Griafolen, Caerhun	Figure 46	Survey plan depicts several roundhouses and field boundaries. Dwelling sites are described as 'probably organically related to the terraces', and it is noted that they may not all be contemporary.	8
Early fields and dwellings near Mean-y-Bardd, Caerhun	Figure 47	Survey plan depicts early terraced fields; discussion of field boundaries and their preservation.	130
Early fields and dwellings, north of Pen-y-gaer, Caerhun	Figure 50	Survey plan depicts early cultivation terraces and boundary banks associated with round or rectangular buildings.	135
Huts and Enclosure on Moel Eilio, Dolgarrog	Figure 77	Survey plan showing enclosures and round huts.	3
Early fields and dwellings south of Pen-y-gaer, Llanbedr-y-Cennin	Figure 101	Survey plan depicts ancient field boundaries.	75

Early fields and dwellings west of Garreg-fawr, Llanfairfechan	Figure 118	Survey plan depicts an ‘extensive and well-preserved field system.’	52
Huts and Enclosures in Cwm Caseg, Llanllechid	Figure 136	Survey plan depicts roundhouses and enclosures.	13
Early fields and dwellings east of Llanllechid	Figure 138	Survey plan depicts early fields.	59
Huts and fields on Moel Faban, Llanllechid	Figure 143	Survey plan depicts huts and fields.	19

Table B2

RCAHMW (1960) Caernarvonshire Volume 2: Central

Survey name	Reference	Summary of features depicted on survey plan (use of original terms)	Survey area (hectares)*
Huts and early field systems near Bryn Mair, Betws Garmon and Llanwnda	Figure 36	Survey plan depicts several huts and identifies early field systems.	52
Early fields and Dwellings, Caerau, Clynnog	Figure 42	Survey plan depicts huts and fields covering an area of about 134 acres.	92
Huts and enclosures near Ceunant Y Ddol, Dolbenmaean	Figure 73	Survey plan depicts ancient and walls, and 19 out of 20 round huts that were identified as part of a settlement group.	23
Hillfort of Tre'r Ceiri, Llanaelhaearn	Figure 83	Survey plan depicts stone huts (approximately 150), along with extensive enclosure walls outside the ramparts.	10
Huts and fields near Tyddyn-Mawr, Llanaelhaearn	Figure 89	Survey plan depicts old walls and hut, described as an area of small early terraced fields covering about 14 acres.	9
Hut group and fields near Cwm-Ceiliog, Llanaelhaearn	Figure 91	Survey plan depicts huts groups and system of small terraced fields to the north and south of the hut group, covering an area of about 5 acres.	7
Huts and fields near Cae'r-Odyn, Llandwrog	Figure 130	Survey plan depicts huts and field systems, described as 'well-marked fields and terraces contemporary with the hut-group' extending along the slopes to the north-east and south-west of the site.	42
Early remains near Nantlle, Llandwrog (west part, east part)	Figures 132 & 133	Survey plan depicts an extensive and generally well-preserved series of huts with associated fields systems. The whole system is thought to have extended over a total length of nearly 2 miles, though some intervening remains have been obliterated by agriculture and extensive quarrying.	76 82

Huts and fields, near Gaerwen, Llanwnda	Figure 157	Survey plan depicts huts and fields near Gaerwen, including a number of well-defined ancient field walls running in more or less straight lines and enclosing roughly rectangular plots.	60

Table B3

RCAHMW (1964) Caernarvonshire Volume 3: West

Survey name	Reference	Summary of features depicted on survey plan (use of original terms)	Survey area (hectares)*
Hillfort on Garn Boduan, Boduan	Figure 53	Survey plan depicts approximately 170 huts within the hillfort and 'ancient disconnected slight walling' outside the ramparts to the east.	27
Hillfort on Carn Fadruan, Llaniestyn	Figure 85	Survey plan depicts huts and enclosure walls within ramparts of hillfort; huts and enclosure walls also shown outside the ramparts on all sides of the hillfort.	55
Huts and fields at Rhiw	Figure 113	Survey plan depicts round huts and long huts on the south-east slopes of Mynydd Rhiw	93

Appendix C: Upland survey project work in northwest Wales (2003-2015)

*Survey areas based on GIS calculations not original reporting

**Digital records refers to records held in the National Monument Record (NMR) or regional Historic Environment Record (HER)

Upland survey project name	Survey date	Reference	Fieldworkers	Survey area (km^2)*	Aerial mapping by RCAHMW staff	Field survey work	Additional notes on integration into digital record holdings**
Eastern Snowdonia	2003	(Scott Jones 2003)	Richard Scott Jones	31.8	447 polygon records	No digital assets created	Transcription of RAF vertical APs by RCAHMW staff
Dyffryn Mymbyr Historical and Archaeological Survey	2004	(Laws and Brooks 2004)	Ian Brooks; Kathy Laws	12.3	30 polyline records	No new digital assets created	Transcription of RAF vertical APs by RCAHMW staff
Eastern Snowdonia (North) Penmaenmawr-Rowen	2003-2004	(Schofield 2004)	Peter Schofield; Andy Lane	33.6	642 polygon records	Access database created for new sites	Transcription of RAF vertical APs by RCAHMW staff
Eastern Snowdonia (Central) Tal-y-bont uplands	2004-2005	(Schofield 2005)	Ben Curtis; Andy Lane; Chris Ridings; Peter Schofield; Martin Sowerby	9.7	164 polygon records	Digital point data created	Transcription of RAF vertical APs by RCAHMW staff
Nantlle to Beddgelert (North)	2005-2006	(Schofield 2006)	Peter Schofield; Alastair Vannan	22.6	350 polygon records; 27 polyline records	No new digital assets created	Transcription of Ordnance Survey vertical APs by RCAHMW staff

Nantlle Beddgelert (South)	2005-2006	(Roseveare 2008)	Dafydd Collins; Samantha Lowden; Sam Meadows; Elke Nagel; Anne Roseveare; Huw Sherlock; Nico Vaughan	36.6	36 polylines, 207 polygons	No new digital assets created	Transcription of Ordnance Survey vertical APs, RAF Vertical APs and RCAHMW Oblique APs by RCAHMW staff
Llanegryn Uplands Archaeological Survey	2007	(Laws and Brooks 2007)	Ian Brooks; Kathy Laws	47.2	175 polygon records	Polygon; polyline; point data	Transcription of Ordnance Survey vertical APs by RCAHMW staff; field survey staff created point data integrated into NMR; no concordance with National Trust and HER records
Snowdonia (Bethesda) Survey	2007-2008	(Schofield 2008a)	Peter Schofield; Will Gardner	25.8	19 polyline records	GIS data created (MapInfo files)	Transcription of RAF vertical APs and 2006 WAG APs by RCAHMW staff
Snowdonia (North-West) Survey	2007-2008	(Schofield 2008b)	Peter Schofield; Rebecca Briscoe; Daniel Taylor; Will Gardner	27.0	551 polygon records	No new digital assets created	Transcription of RAF vertical APs and Ordnance Survey vertical APs by RCAHMW staff
Yr Aran	2011	(Hayman and Horton 2011)	Richard Hayman and Wendy Horton	9.7	117 polyline records	GIS point data created	Transcription of WAF APs by RCAHMW staff

Moel-Siabod (North)	2010	(Railton 2011)	Angus Clark; Tony Liddell; Don O-Meara; Kevin Mounsey	c.25.0	83 polyline records	137 new sites	Transcription of Ordnance Survey, WAG and RAF vertical APs by RCAHMW staff
Llyn Cowlyd-Capel Curig	2013-2014	(Kenney 2014)	Jane Kenney; Dave Hopewell	13.5	None created	572 new sites Polygon, polyline and point data	Field survey report mentions Tir Gofal sites not originally incorporated into the HER
Moel Ysgyfarnogod	2014-2015	(Hall and Sambrook 2015)	Jenny Hall; Paul Sambrook	18.0	None created	GIS point data created	-

Total survey areas	Survey date span	Number of unpublished reports	Number of fieldworkers	Total Survey area (km^2)*	Aerial mapping by RCAHMW staff	Field survey work	
13	2003-2015	13	29	c. 312	Minimum 2,390 polygons and 310 polyline records	Not consistently recorded / not applicable	-

Appendix D: Sites where there are radiocarbon dates for occupation

Based on Waddington (2010b: 89), with new additions. Sites in **bold** lie within the study area.

Type	Name	Radiocarbon dates	Primary Record Number (PRN)	Site code (Waddington 2013)
Field systems			-	-
Unenclosed	Parc Bryn Cegin B	Not agreed	33516	GA200
	Cyfanedd Fawr	**3**	**4907**	**GM150**
	Crawcwellt West	**2**	**5160**	**GM137**
	Hengwm	**4**	**1165**	**GM186**
	Pant	**3**	**148**	**GD311**
	Parc Bryn Cegin F and G	Not agreed	33514	GA199
	Cefn Du	5	33505	AN65
	Cefn Cwmwd	10	33501	AN64
	Melin y Plas	10	3345	AN76
	Bush Farm	**1**	**3463**	**GA25**
Enclosed	Mellteyrn Uchaf	7	1695	GD77
	Erw Wen	**3**	**1036**	**GM55**
	Moel y Gerddi	**7**	**1003**	**GM76**
	Llandygai B		2312	GA70
	Llandygai A	1	2311	GA69
	Ty Tan Dderwen		9982	GM84
	Bryn Eryr	27	401	AN22
	Parc Bryn Cegin N	Not agreed	33511	GA80
	Ty Mawr	7	33550	AN55
	Graeanog E	14	117	GD67
	Llanbedrgoch	23	5348	AN41
Double ringworks	Castell Odo	4	767	GD12
	Meillionydd	n/a	1205	GD22
Hillforts	**Conwy Mountain**	**4**	**2816**	**AB5**
	Pen y Dinas		637	AB11
	Bryn y Castell	**18**	**1489**	**GM2**

Appendix E: National Mapping Programme (NMP) studies

*Rapid Coastal Zone Assessment survey (RCZAS), **Aggregate Levy Sustainability Fund (ALSF)

NMP mapping project name	Survey date	Additional information
Yorkshire Wolds	February 1981 - December 1991	pre-NMP project
Kent	October 1986 - October 1987	pilot NMP project
Thames Valley	June 1988 - November 1994	pilot NMP project
Hertfordshire	June 1989 - November 1992	pilot NMP project
Yorkshire Dales	February 1989 - July 1992	pilot NMP project
Howgill Fells	June 1992 - January 1994	
Lincolnshire	July 1992 - March 1997	
National Forest	August 1992 - March 1995	
Howardian Hills	April 1993 - January 1994	
Marches Uplands	June 1993 - October 1994	Aerial photographs (Stoertz 2004)
Salisbury Plain Training Area	December 1994 - August 1995	
Berkshire	November 1995 - January 1999	
Avebury World Heritage Site	October 1997 - December 1998	
Brendon Hills	January 1998 - October 1998	
Vale of York	January 1998 - December 2000	
Lambourn Downs	January 1999 - April 2000	
Malvern Hills AONB	July 2000 - January 2001	
Stonehenge World Heritage Site	February 2001 - July 2001	
Nottinghamshire	July 1993 - January 1997	Carried out externally, i.e. not part of the formal NMP or funded by English Heritage
Cornwall	January 1994 - spring of 2006	Aerial photographs (Cornwall County Council Historic Environment Service 2007) Project data integrated into Cornwall HER Polygons and polylines shown on County Council interactive map

Northamptonshire	1994 – August 2001	Aerial photographs (Deegan 2002, Foard and Deegan 2007) MORPH2.2 mapping conventions Project data integrated into Northamptonshire HER GIS files archived with ADS, downloadable and include metadata; viewable on general interactive map
Thornborough Henges: Air Photo Mapping Project		
Suffolk (RCZAS*)	April 2001 - March 2004	(Hegarty and Newsome 2005)
East Yorkshire (ALSF** project)		
Essex (ALSF project)		
Hampshire (ALSF project)		
Leadon Valley (ALSF project)		
Magnesian Limestone (ALSF project)		
Norfolk (ALSF project)		
Somerset (ALSF project)		
Suffolk (ALSF project)		
Till Tweed (ALSF project)		
Warwickshire (ALSF project)		
Alston Moor, North Pennines	August 2009 - June 2011	Aerial photographs and lidar (Oakey et al. 2012)
Staffordshire phase 1	March 2013 - June 2014	Aerial photographs and lidar (Bax 2014) Total area of 265 km^2 Monument data included on PastScape website Monument data incorporated into HER
Staffordshire phase 2	July 2014 – July 2015	Aerial photographs and lidar (Bax 2015) Total area of 162 km^2
Yorkshire Henges Environs Project	June 2008 - January 2013	Aerial photographs and lidar (Deegan 2013) Total area of 586 km^2 Monument data included on PastScape website
South Downs		Aerial photographs and lidar (Carpenter et al. 2016)
Cheshire	July 2015 – December 2016	Aerial photographs and lidar (Hardwick 2017) Total area of 206 km^2
Staffordshire		Aerial photographs and lidar (Carpenter et al. 2018)

Appendix F: Example layer metadata used in transcriptions of fieldscapes

Table F1

Northamptonshire (Deegan 2002)

Layer content	Layer digitising	Layer colour
Geological anomalies	Polyline, Solid Region	Yellow
Modern feature	Polyline, Solid Region	Magenta
Ditches and foundations	Solid Polyline, Solid Region	Black
Bank	Dotted Polyline	Black
Maculae and outlined features	Dashed Polyline	Black
Internal bank material	Wide Dashed Polyline	Black
Earthwork slope	Uniform Hachures (MI generated linetype)	Black
Earthwork slopes	T Hachures (Hand generated)	Black
Earthwork slopes	Hachures (Hand generated)	Black
Banks, foundations and soilmark ditches	Coarse Dot Region	Black
Banks and foundations	Medium Dot Region	Black
Banks and foundations	Fine Dot Region	Black
Foundations	V. Fine Dot Region	Black
Outline of large maculae	No Fill Region, Dashed Outline	Black
Ridge and furrow	No Fill Region, Dashed Outline Polyline (hand drawn or MI arrows)	Green

Table F2

Yorkshire Henges and Environs (Deegan 2013)

Layer name	Layer content	Layer colour
BANK	Closed polygons for supra-surface earthen features such as banks, platforms, mounds and spoil heaps	1 (red)
DITCH	Closed polygons for cut or wear features such as ditches, pits and hollows	3 (green)
EXTENT OF AREA	Closed polygons outlining complex or extensive remains such as mining or military camps	30 (orange)
MONUMENT POLYGON	Closed polygons encircling all the features recorded within a single NMR record	7 (white)
RIGARREWK	Polyline showing the plough direction of earthwork ridge and furrow	4 (cyan)
RIGARRLEVEL	Polyline showing the plough direction of levelled or crop mark ridge and furrow	6 (magenta)
RIGDOTSLEVEL	Closed polygon defining the furlongs or extent of ridge and furrow	4 (cyan)
STRUCTURE	Stone, metal and timber features, structures and erections	52 (white)
THACHURE	convention to schematize the top and direction of slope	5 (blue)

Table F3
Staffordshire (Bax 2014)

EH Layer Name	EH layer content	EH Layer colour
BANK	Closed polygons for features such as banks, platforms, mounds and spoil heaps	1 (red)
DITCH	Closed polygons for cut features such as ditches, ponds, pits or hollow ways	3 (green)
EXTENT_OF_FEATURE	Closed polygons outlining complex or extensive remains such as mining or military installations	30 (orange)
MONUMENT_ POLYGON	Closed polygons encircling all the features recorded within a single NRHE record	7 (white)
RIDGE_AND_FURROW_ALIGNMENT	Polyline showing the direction of ploughing of ridge and furrow	4 (cyan)
RIDGE_AND_FURROW_AREA	Closed polygon defining the furlongs or extent of area of ridge and furrow	4 (cyan)
STRUCTURE	Closed polygons for built features including concrete, metal and timber constructions such as military installations	190 (purple)
THACHURE	Polyline T-hachure convention to schematize sloped features indicating the top of slope and direction of slope	5 (blue)

Appendix G: Geospatial datasets used in digitising process

GIS resource description	Description, including data type, geometry type and lineage	Processing details	Layer title(s)
Lidar datasets	Composite lidar digital surface models (DSMs) at 1m resolution • Data type: Raster Dataset • Data format: AAIGrid and TIFF • Lineage: created by various agencies and combined by NRW, and supplied the Welsh Government via Lle portal	Individual tiles combined into larger seamless layers and processed using RVT to create .tif files.	Multiple layers using the following format, where 0000 represents a tile reference (e.g. SH5052) and PROCESSTYPE equals visualisation: sh0000_dsm_1m_mosaic_PROCESSTYPE
	Composite lidar digital terrain models (DTMs) at 1m resolution • Data type: Raster Dataset • Data format: AAIGrid and TIFF • Lineage: created by various agencies and combined by NRW, and supplied by the Welsh Government via Lle portal	Individual .asc tiles combined into larger seamless layers and processed using RVT to create .tif files.	Multiple layers using the following format, where 0000 represents a tile reference (e.g. SH5052) and PROCESSTYPE equals visualisation: sh0000_dtm_1m_mosaic_PROCESSTYPE
Index to lidar datasets	Coverage of composite lidar DTMs, pre-2014 • Data type: Shapefile Feature Class • Geometry type: polygon • Lineage: created by NRW, and supplied by the Welsh Government via Lle portal	No additional processing	Lidar_used_in_merging_process _2014_NRW
	Coverage of composite lidar DTMs, pre-2015 • Data type: Shapefile Feature Class • Geometry type: polygon • Lineage: created by NRW, and supplied by the Welsh Government via Lle portal	No additional processing	Lidar_used_in_merging_process _2015_NRW

Index to lidar datasets (continued)	Coverage of all 1m resolution lidar DTMs, pre-2017 • Data type: Shapefile Feature Class • Geometry type: polygon • Lineage: created and supplied by the RCAHMW	No additional processing	Lidar coverage_1m
	Coverage of all 2m resolution lidar DTMs, pre-2017 • Data type: Shapefile Feature Class • Geometry type: polygon • Lineage: created and supplied by the RCAHMW	No additional processing	Lidar coverage_2m
Historic mapping layers	6-inch (1:2500) County Series, including 1st edition (1853-1904), First Revision (1894-1915), Second Revision (1906-1939) Ordnance Survey maps • Data type: Raster Dataset • Format: TIFF • Lineage: supplied by Digimap • Copyright: Crown Copyright and Landmark Information Group Limited	Some individual tiles combined into larger seamless layers	Multiple layers using the following format, where 00 represents a tile reference (e.g. SH50): sh00_firstedition sh00_secondedition sh00_thirdedition
	25-inch (1:10 560) 1st edition (1846-1899) County Series Ordnance Survey maps • Data type: Raster Dataset • Format: TIFF • Lineage: supplied by Digimap • Copyright: Crown Copyright and Landmark Information Group Limited	Some individual tiles combined into larger seamless layers	Multiple layers using the following format, where 00 represents a tile reference (e.g. SH50): sh00_firstedition
Natural colour aerial photography	Natural colour aerial photographs • Data type: Raster Dataset • Format: AMD • Lineage: supplied by SNPA	Individual files combined into seamless layers	Four layers for different years: Aerial_photo_2000 Aerial_photo_2006 Aerial_photo_2009 Aerial_photo_2013

Colour infrared aerial photography	Colour infrared aerial photographs • Data type: Raster Dataset • Format: AMD • Lineage: supplied by SNPA	Individual files combined into seamless layers	Three layers for different years: CIR_2013_2014 CIR_2015 CIR_2016
Monument data	Seamless spatial dataset showing Scheduled Monuments as polygons • Data type: Shapefile Feature Class • Geometry type: polygon • Lineage: created by Cadw and supplied by the Welsh Government via Lle portal	No additional processing	Cadw_SAMPolygon
	National Monument Record records, referenced using National Record Number (NPRN) • Data type: Shapefile Feature Class • Geometry type: point • Lineage: created and supplied by RCAHMW	No additional processing	NPRN_records
	Regional Historic Environment records, referenced using Primary Record Number (PRN) • Data type: Shapefile Feature Class • Geometry type: line • Lineage: created and supplied by the regional HER	Original data supplied as an Excel (.xlsx) file and converted to point data using NGR fields	Sep2019_GAT_HER_Core
	Polyline spatial dataset depicting route of Roman roads • Data type: Shapefile Feature Class • Geometry type: line • Lineage: created by GAT (Hopewell 2004, Hopewell 2007) and supplied by the regional HER	Original data supplied as a Mapinfo MID and MIF file; converted to line shapefile	Roman_Roads_Final_version-line

RCAHMW surveys (1937-1962)	RCAHMW archaeological survey plans made between 1937 and 1962 • Data type: Raster Dataset • Format: JFIF • Lineage: surveys carried out by RCAHMW staff (RCAHMW 1956, RCAHMW 1960, RCAHMW 1964)	Original surveys scanned and georeferenced	25 layers for different survey maps, using the following format, where xx represents the original figure number: Fig xx.jpg
	Index to RCAHMW archaeological survey plans made between 1937 and 1962 • Data type: Shapefile Feature Class • Geometry type: polygon • Lineage: created as part of Snowdonia's Early Fieldscapes PhD research	No additional processing	RCAHMW survey areas
Radiocarbon dates	Radiocarbon dates in Wales, with sites included up until 2015 • Data type: Shapefile Feature Class • Geometry type: point • Lineage: Excel spreadsheet created and supplied by the National Museum of Wales (Burrow and Williams 2008) in 2017	Original data supplied as an Excel (.xlsx) file and converted to point data using NGR fields	Radiocarbon dates
Medieval field systems study	Areas investigated as part of study of medieval field systems • Data type: Shapefile Feature Class • Geometry type: polygon • Lineage: created by GAT (Kenney 2015) and supplied by the regional HER	Original data supplied as a MapInfo MID and MIF file; converted to shapefile	Medieval field systems survey, 2015

Medieval field systems study (continued)	Individual lines of ridge and furrow identified through the analysis of aerial photographs • Data type: Shapefile Feature Class • Geometry type: line • Lineage: created by GAT (Kenney 2015) and supplied by the regional HER (GAT)	Original data supplied as a MapInfo MID and MIF file; converted to shapefile	G2156_APs_line
	Individual lines of ridge and furrow identified through the analysis of aerial photographs • Data type: Shapefile Feature Class • Geometry type: polygon • Lineage: created by GAT (Kenney 2015) and supplied by the regional HER	Original data supplied as a MapInfo MID and MIF file; converted to shapefile	G2156_APs_polygon
	Ridge and furrow identified through the analysis of 25-inch historic Ordnance Survey maps • Data type: Shapefile Feature Class • Geometry type: line • Lineage: created by GAT (Kenney 2015) and supplied by the regional HER	Original data supplied as a MapInfo MID and MIF file; converted to shapefile	G2156_25inchmap_line
	Ridge and furrow identified through the analysis of 25-inch historic Ordnance Survey maps • Data type: Shapefile Feature Class • Geometry type: line • Lineage: created by GAT (Kenney 2015) and supplied by the regional HER	Original data supplied as a MapInfo MID and MIF file; converted to shapefile	G2156_lidar_line
Upland survey data	Archaeological features transcribed from vertical and oblique aerial photographs • Data type: Shapefile Feature Class • Geometry type: line • Lineage: created and supplied by RCAHMW	No additional processing	AP_Mapping_Features_(BNG)_RCAHMW_pli

Upland survey data (continued)	Archaeological features transcribed from vertical and oblique aerial photographs • Data type: Shapefile Feature Class • Geometry type: polygon • Lineage: created and supplied by RCAHMW	No additional processing	AP_Mapping_Features_(BNG)_RCAHMW_ply
	Areas where archaeological features transcribed from vertical and oblique aerial photographs • Data type: Shapefile Feature Class • Geometry type: polygon • Lineage: created and supplied by RCAHMW	No additional processing	RCAHMW upland survey, 2003-2014
Environmental datasets	Land cover specifying 21 different land-use types in Great Britain compiled in 2015, released in April 2017 • Data type: Shapefile Feature Class • Geometry type: polygon • Lineage: created by the UK Centre for Ecology and Hydrology (CEH) (Rowland 2017) and supplied by Digimap	Sub-set of data selected for study area	LCM2015GBvector_Intersect
	The 'Unified Peat Map of Wales' shows all identified areas of peat • Data type: Shapefile Feature Class • Geometry type: polygon • Lineage: created by Natural Resources Wales (NRW) based on a combination 4 map sources - the British Geological Survey (BGS) surface peat, Forestry Commission survey peats, lowland peat survey (NRW) and Phase 1 habitat peats (all E class with the exception of E2); dataset supplied by the Welsh Government via Lle portal	Sub-set of data selected for study area	NRW Unified Peat Layer
	Boundaries of Sites of Special Scientific Interest (SSSIs) in Wales • Data type: Shapefile Feature Class • Geometry type: polygon • Lineage: created by Natural Resources Wales (NRW); dataset supplied by the Welsh Government via Lle portal	Sub-set of data selected for study area	NRW_SSSI_2018_12

Geological and soil datasets	Bedrock geology at 1:250,000 • Data type: Shapefile Feature Class • Geometry type: polygon • Lineage: created by British Geological Survey in 2008 and supplied by Digimap	No additional processing	sh_v4_bedrock
	Soil parent material at 1:50,000 • Data type: Shapefile Feature Class • Geometry type: polygon • Lineage: created by British Geological Survey in 2008 and supplied by Digimap	No additional processing	16 different layers
	National Superficial Deposits Thickness Model (SDTM) demonstrates the variation in thickness of Quaternary-age superficial deposits across Great Britain at 1:50,000 • Data type: Shapefile Feature Class • Geometry type: polygon • Lineage: created by British Geological Survey (BGS) in 2010 (Lawley and Garcia-Bajo 2010) and supplied by Digimap	No additional processing	astm-v5 dbuf-v5
Ordnance Survey data	Modern topographic lines • Data type: File Geodatabase Feature Class • Geometry type: line • Lineage: created by the Ordnance Survey and supplied by Digimap	Combine into seamless layers	Topographic lines
	Modern water courses • Data type: File Geodatabase Feature Class • Geometry type: line • Lineage: created by the Ordnance Survey and supplied by Digimap	No additional processing	WatercourseLink

Base maps	Ordnance Survey terrain 50m interval data • Data type: Raster Dataset • Format: AAIGrid • Lineage: created by the Ordnance Survey and supplied by Digimap	No additional processing	Multiple layers for different Ordnance Survey tiles
	Ordnance Survey contour 50m interval data • Data type: Shapefile Feature Class • Geometry type: line • Lineage: created by the Ordnance Survey and supplied by Digimap	No additional processing	Multiple layers for different Ordnance Survey tiles
	Modern Ordnance Survey maps at 1:25,000 • Data type: Raster Dataset • Format: TIFF • Lineage: created by the Ordnance Survey and supplied by Digimap	No additional processing	Multiple layers for different Ordnance Survey tiles
	Ordnance Survey background maps • Lineage: created by the Ordnance Survey and supplied by Digimap	No additional processing	OS_Open_Background_2
	One meter or better satellite and aerial imagery worldwide. • Lineage: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community	No additional processing	World Imagery (WGS84)

Appendix H: Selected geospatial attribute fields

Table H1

RCAHMW aerial mapping

Field name	Data Type (width)
FID	Object ID
Shape	Geometry
FEATURE	String (50)
SOURCE	String (250)
COMMENTS	String (250)
SCALE	String (10)
CERTAINTY	String (250)
COMPILER	String (10)
COMPILEDON	String (50)
NPRN	String (20)
COPYRIGHT	String (20)
FIELDCHECK	String (50)
ACCURACY	String (250)
PROJTITLE	String (250)

Table H2

Medieval fields project (Kenney 2015)

Point data Field name	Polylines Field name	Polygons Field name	ALL Data types Data type (width)
OBJECTID	OBJECTID	OBJECTID	Object ID
SHAPE	SHAPE	SHAPE	Geometry
Unique_ID	Unique_ID	Unique_ID	String (12)
GAT_HER_PRN	GAT_HER_PRN	GAT_HER_PRN	Numeric Number format (Long)
PRN_Type	PRN_Type	PRN_Type	String (10)
Spatial_Feature_Type	Spatial_Feature_Type	Spatial_Feature_Type	String (10)
Area_Type	Area_Type	Area_Type	String (10)
Data_Capture_Method	Data_Capture_Method	Data_Capture_Method	String (20)
Data_source	Data_source	Data_source	String (20)
Buffer_Zone_Width	Buffer_Zone_Width	Buffer_Zone_Width	String (10)
Positional_Accuracy	Positional_Accuracy	Positional_Accuracy	String (20)
X_Coordinate	X_Coordinate	X_Coordinate	String (10)
Y_Coordinate	Y_Coordinate	Y_Coordinate	String (10)
Originating_Organisation	Originating_Organisation	Originating_Organisation	String (10)
Compiled_by	Compiled_by	Compiled_by	String (10)
Compiled_on	Compiled_on	Compiled_on	String (10)
Last_update_by	Last_update_by	Last_update_by	String (10)
Last_update_on	Last_update_on	Last_update_on	String (10)
Copyright	Copyright	Copyright	String (10)
Notes	Notes	Notes	String (200)
	SHAPE_Length	SHAPE_Length	Double
		SHAPE_Area	Numeric number format (Double)

Appendix I: Early fieldscapes metadata for primary new datasets

Table I1

Geodatabase entities and table references

Geodatabase	Layer object	Sub-types	Domains
Fieldscapes (Table I2)	Transcription (Tables I3 and I4)	Feature (Table I5)	Data source (Table I6) Positional accuracy (Table I7) Priority level (Table I8) Yes/No (Table I9) Digitising scale (Table I10) Compiler (Table I11)
	Research Categorisation (Tables I12 and I13)	Monument (Table I14)	Period (Table I15) Dating type (Table I16) Priority level (Table I8) Yes/No (Table I9) Digitising scale (Table I10) Compiler (Table I11)

Table I2

Fieldscapes geodatabase metadata

Metadata date	2020-12-10
Metadata point of contact	Emily La Trobe-Bateman, PhD student 2016-2020, University of Sheffield, Sheffield, UK
Metadata standard name	UK GEMINI
Metadata standard version	2.3
Metadata language	English
Resource type	Dataset

Abstract	Archaeological features identified through analysis of aerial reconnaissance surveys such as lidar and aerial photography
Alternative title	Snowdonia's early fieldscapes
Bounding box	Longitude: westbound -4.49 degrees and eastbound -3.78 degrees; Latitude: southbound 52.59 degrees and northbound 53.29 degrees
Conformity	Not evaluated
Data format	File Geodatabase
Dataset language	English
Dataset reference date	2020-11-10
Hardware	Processor: Intel® Core ™ i7-6700HQ CPU @ 2.60GHz Installed RAM: 16GB System type: 64-bit operating system, x64-based processor
Keywords	ARCHAEOLOGY: Discipline
Limitations on public access	Use of this Data is restricted to training, demonstration, and educational purposes only. This Data cannot be sold or used without the express written consent of Emily La Trobe-Bateman.
Lineage	PhD research
Maintenance information	Not planned
Method of original data capture	Heads-up digitising using Wacom Intuos Pro™ large pen tablet: Model PTH-851, Control Panel Version 6.3.15-3, Driver Version 6.3.15-3
Resource identifier	EFS2020
Resource locator	https://orda.shef.ac.uk/ DOI: 10.15131/shef.data.c.5711738
Responsible organisation	Emily La Trobe-Bateman, PhD student 2016-2020, University of Sheffield, Sheffield, UK: owner, originator, point of contact, principal investigator, author
Software	ArcGIS 10.6 and 10.7.1 for Desktop Licence type: Advanced
Spatial reference system	British National Grid, Transverse Mercator GCS Ordnance Survey Great Britain (OSGB) 1936
Spatial representation type	1. vector
Temporal extent	2016-09-01 to 2020-11-10
Title	Fieldscapes
Topic category	SOCIETY
Use constraints	Copyright, Emily La Trobe-Bateman

Table I3

Transcription layer metadata

Metadata date	2020-12-10
Metadata point of contact	Emily La Trobe-Bateman, PhD student 2016-2020, University of Sheffield, Sheffield, UK
Metadata standard name	UK GEMINI
Metadata standard version	2.3
Metadata language	English
Parent identifier	Fieldscapes geodatabase
Resource type	Dataset

Abstract	Archaeological features identified and transcribed as polygonal objects through analysis of aerial reconnaissance surveys such as lidar and aerial photography
Alternative title	Transcribed archaeological features
Bounding box	Longitude: westbound -4.49 degrees and eastbound -3.78 degrees; Latitude: southbound 52.59 degrees and northbound 53.29 degrees
Conformity	Not evaluated
Data format	Geodatabase Feature Class
Dataset language	English
Dataset reference date	2020-11-10
Hardware	Processor: Intel® Core ™ i7-6700HQ, CPU @ 2.60GHz Installed RAM: 16GB System type: 64-bit operating system, x64-based processor
Keywords	ARCHAEOLOGY: Discipline
Limitations on public access	Use of this Data is restricted to training, demonstration, and educational purposes only. This Data cannot be sold or used without the express written consent of Emily La Trobe-Bateman.
Lineage	PhD research
Maintenance information	Not planned
Method of original data capture	Heads-up digitising using Wacom Intuos Pro™ large pen tablet: Model PTH-851, Control Panel Version 6.3.15-3, Driver Version 6.3.15-3
Resource identifier	EFS2020
Resource locator	https://orda.shef.ac.uk/ DOI: 10.15131/shef.data.c.5711738
Responsible organisation	Emily La Trobe-Bateman, PhD student 2016-2020, University of Sheffield, Sheffield, UK: owner, originator, point of contact, principal investigator, author.
Software	ArcGIS 10.6 and 10.7.1 for Desktop Licence type: Advanced
Spatial reference system	British National Grid, Transverse Mercator GCS Ordnance Survey Great Britain (OSGB) 1936
Spatial representation type	1. vector
Temporal extent	2016-09-01 to 2020-11-10
Title	Transcription
Topic category	SOCIETY
Use constraints	Copyright, Emily La Trobe-Bateman

Table I4

Transcription attribute fields

Field name	Data type (width)	Allow nulls	Subtype	Domain	Default coded value
OBJECTID	Object ID				Automatic
SHAPE	Geometry	No			Automatic
SHAPE_Area	Double	No			Automatic
SHAPE_Length	Double	No			Automatic
created_date	Date	No			Automatic
Last_update_by	Date	No			Automatic
last_edited_date	Date	No			Automatic
Feature	Short Integer	No	Feature type		1
Data_source	Short Integer	No		Data source	1
Positional_accuracy	Short Integer	No		Positional accuracy	2
Digitising_scale	Numeric	No		Scale	2
Recommend_field_visit	Short Integer	No		Priority level	1
Additional_digitising_ data_source _information	String (250)	Yes			Optional
Transcription_comments	String (250)	Yes			Optional
Field_visit	Short Integer	No		Yes/No	1
Field_check_by	Short Integer	Yes		Compiler	1
Field_check_on	Date	Yes			Optional
Field_notes	String (250)	Yes			Optional
Photograph_reference	String (250)	Yes			Optional

Table I5

Feature subtype coded values

Code	Label	Description*
1	BANK	Linear or curvilinear construction of earth, turf and/or stone, often, but not always accompanied by a ditch. https://heritagedata.org/live/schemes/10/concepts/91126.html
2	DITCH	A long and narrow hollow or trench dug in the ground, often used to carry water though it may be dry for much of the year. https://heritagedata.org/live/schemes/10/concepts/70351.html
3	LYNCHET	Manmade broad earth terrace or flat strip of land on a slope.**
4	WALL	An enclosing structure composed of bricks, stones or similar materials, laid in courses. http://purl.org/heritagedata/schemes/10/concepts/70426
5	STRUCTURE	A construction of unknown function, either extant or implied by archaeological evidence. http://purl.org/heritagedata/schemes/10/concepts/70420
6	PIT	A hole or cavity in the ground, either natural or the result of excavation. http://purl.org/heritagedata/schemes/10/concepts/70398
7	MOUND	An artificial elevation of earth or stones. http://purl.org/heritagedata/schemes/10/concepts/70382
8	HOLLOW	A hollow, concave formation or place, which has sometimes been dug out. http://purl.org/heritagedata/schemes/10/concepts/70376
9	AREA OF CULTIVATION MARKS	Manmade marks or earthworks which provide evidence for agricultural cultivation. http://purl.org/heritagedata/schemes/10/concepts/68618
10	NOT KNOWN	Feature not identified as positive, negative, linear or irregular form.
11	SCREE BANK	Bank with extensive surface stone visible.
12	NULL FEATURE	Feature identified through remote sensing but confirmed as an incorrect identification because of further investigation, such as field work.
13	FLATTENED WIDE BANK	Wide linear feature that appears to be remnants of a bank or boundary, often the result of ploughing out or spread of earth and/or stone over time.

*Terms which follow those described for Wales are referenced; see http://purl.org/heritagedata/schemes/19/concepts/507084
Other terms developed as part of this research
**Term not adopted from linked data vocabulary http://purl.org/heritagedata/schemes/10/concepts/68626 because definition is too narrow, as discussed in the main text

Table I6
Data source domain coded values

Code	Label
1	Lidar Digital Terrain Model (DTM)
2	Lidar Digital Surface Model (DSM)
3	Aerial photograph
4	Field survey

Table I7
Positional accuracy domain coded values

Code	Label
1	POOR: Based on 2m resolution lidar models
2	FAIR: Based on 1m resolution lidar models
3	GOOD: Based on 0.5m resolution lidar models
4	EXCELLENT: Based on 0.25m resolution lidar models
5	GOOD: Based on field survey work
6	POOR: Based on poor quality 1m resolution lidar models
7	GOOD: Based on modern colour aerial photography

Table I8
Priority level domain coded values

Code	Label
1	NOT DETERMINED: Site visit requirement not assessed
2	HIGH: Site visit required
3	MEDIUM: Site visit advised
4	LOW: No site visit recommended

Table I9
Yes/no domain coded values

Code	Label
1	No
2	Yes

Table I10

Digitising scale domain coded values

Code	Label
1	1:2000
2	1:800
3	1:1000

Table I11

Compiler domain coded values

Code	Label
1	Emily La Trobe-Bateman

Table I12

Research Categorisation layer metadata

Metadata date	2020-12-10
Metadata point of contact	Emily La Trobe-Bateman, PhD student 2016-2020, University of Sheffield, Sheffield
Metadata standard name	UK GEMINI
Metadata standard version	2.3
Metadata language	English
Parent identifier	Fieldscapes geodatabase
Resource type	Dataset

Abstract	Archaeological features identified through analysis of aerial reconnaissance surveys such as lidar and aerial photography
Alternative title	Research Categorisation
Bounding box	Longitude: westbound -4.49 degrees and eastbound -3.78 degrees; Latitude: southbound 52.59 degrees and northbound 53.29 degrees
Conformity	Not evaluated
Data format	Geodatabase Feature Class
Dataset language	English
Dataset reference date	2020-11-10
Hardware	Processor: Intel® Core ™ i7-6700HQ CPU @ 2.60GHz Installed RAM: 16GB System type: 64-bit operating system, x64-based processor
Keywords	ARCHAEOLOGY: Discipline
Limitations on public access	Use of this Data is restricted to training, demonstration, and educational purposes only. This Data cannot be sold or used without the express written consent of Emily La Trobe-Bateman.
Lineage	PhD research
Maintenance information	Not planned
Method of original data capture	Heads-up digitising using Wacom Intuos Pro™ large pen tablet: Model PTH-851, Control Panel Version 6.3.15-3, Driver Version 6.3.15-3
Resource identifier	EFS2020
Resource locator	https://orda.shef.ac.uk/ DOI: 10.15131/shef.data.c.5711738
Responsible organisation	Emily La Trobe-Bateman, PhD student 2016-2020, University of Sheffield, Sheffield, UK: owner, originator, point of contact, principal investigator, author.
Software	ArcGIS 10.6 and 10.7.1 for Desktop Licence type: Advanced
Spatial reference system	British National Grid, Transverse Mercator GCS Ordnance Survey Great Britain (OSGB) 1936
Spatial representation type	1. vector
Temporal extent	2016-09-01 to 2020-11-10
Title	Interpretation
Topic category	SOCIETY
Use constraints	Copyright, Emily La Trobe-Bateman

Table I13

Research categorisation attribute fields

Field name	Data type (width)	Allow nulls	Subtype	Domain	Default coded value
OBJECTID	Object ID				Automatic
SHAPE	Geometry	Yes			Automatic
SHAPE_Area	Double	No			Automatic
SHAPE_Length	Double	No			Automatic
created_date	Date	No			Automatic
Last_update_by	Date	Yes			Automatic
Last_update_on	Date	Yes			Automatic
Monument	Short Integer	No	Monument type		1
PERIOD	Short Integer	No		Period	9
Dating_type	Short Integer	No		Date type	5
Digitising_scale	Short Integer	No		Scale	1
Recommend_field_visit	Short Integer	No		Priority level	1
Field_visit_completed	Short Integer	No		Yes/No	1
Specific_date_range	String (50)	Yes			Optional
NPRN	Long Integer	Yes			Optional
PRN	Long Integer	Yes			Optional
Comments	String (250)	Yes			Optional
Field_check_by	Short Integer	Yes		Compiler	Optional
Field_check_on	Date	Yes			Optional
Field_notes	String (250)	Yes			Optional

Table I14

Research categorisation subtype coded values

Code	Label	Description*
1	EARLY FIELD BOUNDARY	The limit line of a field where its association and/or stratigraphic relationship to other features suggest it is pre-medieval in date. Qualified use of 'field boundary' term http://purl.org/heritagedata/schemes/10/concepts/68625
2	EARLY CULTIVATION TERRACE	An area of land, usually on a slope, which has been built up to provide a flat surface for the cultivation of crops. Association and/or their stratigraphic relationship to other features suggest a pre-medieval date. Qualified use of 'cultivation terrace' term http://purl.org/heritagedata/schemes/10/concepts/68620
3	EARLY FIELD**	Area of land enclosed by banks, ditches or walls
4	FIELDSCAPE**	Group of fields, enclosures and houses that are related to one another
5	ENCLOSURE	An area of land enclosed by a boundary ditch, bank, wall, palisade or other similar barrier. http://purl.org/heritagedata/schemes/10/concepts/70354
6	DEFENDED ENCLOSURE	An enclosure, often prehistoric, with more than one earthen bank, other defensive structure or natural feature. http://purl.org/heritagedata/schemes/10/concepts/500309
7	HILLFORT	A hilltop enclosure bounded by one or more substantial banks, ramparts and ditches. http://heritagedata.org/live/schemes/10/concepts/68855
8	ROUNDHOUSE***	A roundhouse indicated by the presence of a low, roughly circular bank of turf, earth or stone, which formed the base of the walls. Characteristic of the later prehistoric period.
9	ROUNDHOUSE *** SETTLEMENT REMAINS	Evidence for a roundhouse(s) indicated by the presence of a low, roughly circular bank of turf, earth or stone, which formed the base of the walls. Characteristic of the later prehistoric period.
10	EARLY SETTLEMENT REMAINS	Evidence for earth and/or stone wall remains that indicate their survival from early settlement.
11	BURIAL CAIRN	A stony mound containing or concealing deliberately deposited human remains. http://purl.org/heritagedata/schemes/10/concepts/68612
12	CLEARANCE CAIRN GROUP	A series of associated irregularly constructed, generally unstructured, mound of stones. Often, but not necessarily, circular. Normally a by-product of field clearance for agricultural purposes. http://purl.org/heritagedata/schemes/10/concepts/68613
13	ROUTEWAY	A route which is not necessarily marked by any visible features. Often with historical associations. http://purl.org/heritagedata/schemes/10/concepts/500249/
14	ROAD	A way between different places, used by horses, travellers on foot and vehicles. http://purl.org/heritagedata/schemes/10/concepts/70264
15	LONG HOUSE	A byre and dwelling under one roof, with a cross passage between them. http://purl.org/heritagedata/schemes/10/concepts/104173

16	LONG CAIRN	A rectangular or trapezoidal non-megalithic stony mound of Neolithic date, with human remains in cists rather than a large chamber. Mound construction and associated features vary considerably in type and complexity. http://purl.org/heritagedata/schemes/10/concepts/70048
17	FORT	A permanently occupied position or building designed primarily for defence. http://purl.org/heritagedata/schemes/10/concepts/68868
18	BURNT MOUND	A mound of fire-cracked stones, normally accompanied by a trough or pit which may have been lined with wood, stone or clay. Assumed to be locations where heated stones were used to boil water primarily for cooking purposes. http://purl.org/heritagedata/schemes/10/concepts/68925
19	RIDGE AND FURROW	A series of long, raised ridges separated by ditches used to prepare the ground for arable cultivation. This was a technique, characteristic of the medieval period. http://purl.org/heritagedata/schemes/10/concepts/68628
20	BARROW	Artificial mound of earth, turf and/or stone, normally constructed to contain or conceal burials. http://purl.org/heritagedata/schemes/10/concepts/70000
21	CHAMBERED TOMB	A Neolithic burial monument comprising a stone-built chamber within a mound of earth or stone. http://purl.org/heritagedata/schemes/10/concepts/70064
22	STONE CIRCLE	An approximately circular or oval setting of spaced, usually freestanding, upright stones. http://purl.org/heritagedata/schemes/10/concepts/70190
23	CAIRNFIELD	A group of cairns occurring within close proximity to each other. Use for instances where the majority are clearance cairns. https://heritagedata.org/live/schemes/10/concepts/68614.html
24	CAIRN	A monument featuring a bank or mound constructed primarily of stone. http://purl.org/heritagedata/schemes/10/concepts/68612

*Terms which follow those described for Wales are referenced; see http://purl.org/heritagedata/schemes/10/concepts/68543
** Term created in advance of digitisation but proved redundant and not used
*** Term not adopted from linked data vocabulary for 'hut circle' because of negative connotations, although definition is accurate http://purl.org/heritagedata/schemes/10/concepts/68964 or 'roundhouse (domestic)' because of definition is too narrow http://purl.org/heritagedata/schemes/10/concepts/94036
Other terms developed as part of this research

Table I15

Period (Wales) domain coded values

Code	Label	Description*
1	IRON AGE	From the introduction of iron working technology around 700 BC to the invasion of Britain by Rome in 43 AD. http://purl.org/heritagedata/schemes/11/concepts/505125
2	EARLY IRON AGE	The period from 700 BC until 400 BC. http://purl.org/heritagedata/schemes/11/concepts/508453
3	MIDDLE IRON AGE	The period between 400 BC to 100 BC. http://purl.org/heritagedata/schemes/11/concepts/508454
4	LATE IRON AGE	The period between 100 BC and 43 CE. http://purl.org/heritagedata/schemes/11/concepts/508455
5	ROMAN	From the invasion of Britain by the Romans in 43 AD to its abandonment by the legions in 410 AD. http://purl.org/heritagedata/schemes/11/concepts/505126
6	PREHISTORIC	All periods up to the invasion of Britain by the Romans in 43 AD. http://purl.org/heritagedata/schemes/11/concepts/505102
7	BRONZE AGE	From the introduction of bronze working technology around 2,200 BC to the beginning of iron working technology around 700 BC. http://purl.org/heritagedata/schemes/11/concepts/505101
8	LATE PREHISTORIC TO EARLY MEDIEVAL	From around 1000 BC to around 1000 AD.
9	UNKNOWN	No known date
10	EARLY MEDIEVAL	From the abandonment of Britain by the Roman legions in 410 AD to the establishment of Norman control over large parts of Wales in 1086. http://purl.org/heritagedata/schemes/11/concepts/505127
11	MEDIEVAL	From the establishment of Norman control over large parts of Wales in 1086 to the Act of Union between England and Wales in 1536. http://purl.org/heritagedata/schemes/11/concepts/505128
12	EARLY MEDIEVAL TO MEDIEVAL	From around 410 AD to 1536 AD.
13	NEOLITHIC TO EARLY IRON AGE	From around 2,200 BC to 400 BC.

*Terms used follow those described for Wales; see http://purl.org/heritagedata/schemes/11

Table I16

Dating type domain coded values

Code	*Label*
1	Absolute date
2	Date based or partly based on stratigraphic relationship to dated sites
3	Date based on morphological analogy with a specific (absolute) dated site
4	Date based on a morphological analogy with a specific (relative) dated site
5	No dating evidence
6	Date based on excavation and/or excavated finds
7	Date based on morphological association with other features

Appendix J: Detailed dataset statistics

Table J1

Transcription dataset

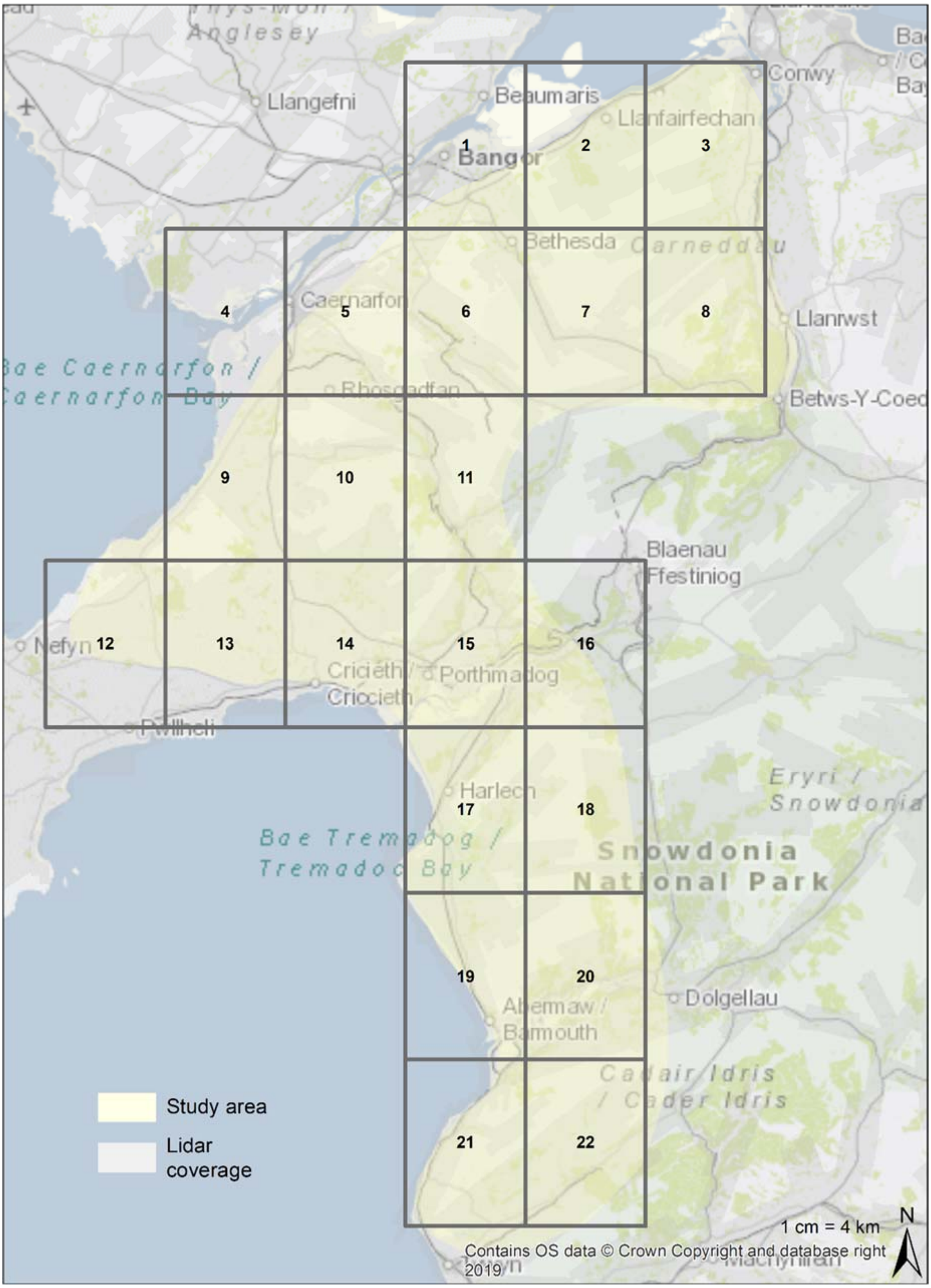
Code	Label	Number of features	Additional sources of information used to assist transcription	Recommendation made for survey	Site visit carried out
1	BANK	7,440	1,681	235	248
2	DITCH	102	46	3	0
3	LYNCHET	840	91	25	22
4	WALL	46	37	0	0
5	STRUCTURE	2	0	2	0
6	PIT	14	0	0	0
7	MOUND	2,494	286	69	66
8	HOLLOW	90	18	10	1
9	CULTIVATION RIDGES	259	34	5	0
10	NOT KNOWN	102	10	12	1
11	SCREE BANK	11	7	0	0
12	NULL FEATURE	3	0	3	0
13	FLATTENED WIDE BANK	2,501	175	5	10
	TOTAL	13,904	2,385	369	348

Table J2

Research categorisation dataset

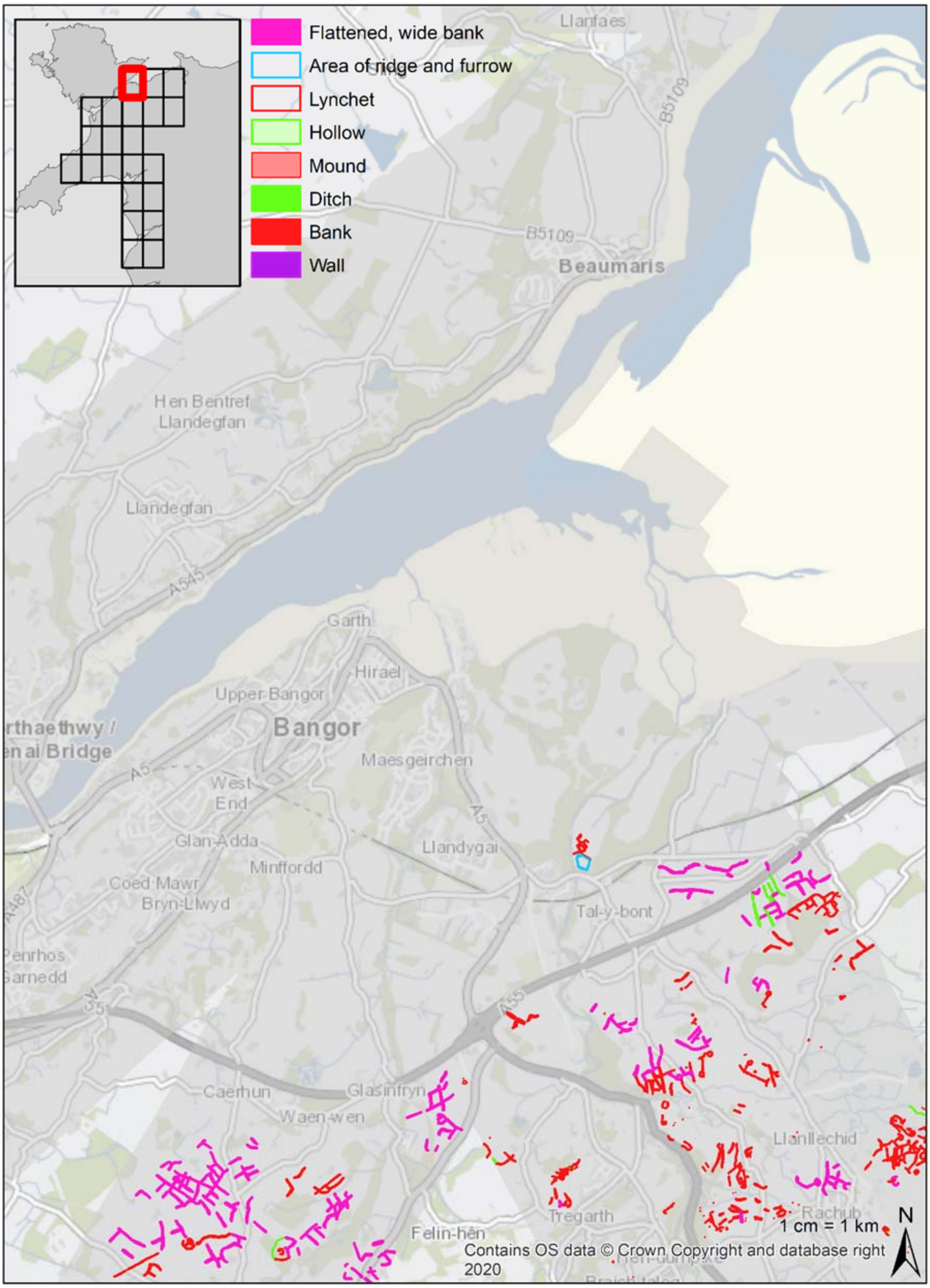
Code	Label	Number of features	NPRN or PRN records
1	EARLY FIELD BOUNDARY	7,302	722
2	EARLY CULTIVATION TERRACE	172	64
3	EARLY FIELD	0	0
4	FIELDSCAPE	0	0
5	ENCLOSURE	240	179
6	DEFENDED ENCLOSURE	15	11
7	HILLFORT	28	27
8	ROUNDHOUSE	268	246
9	ROUNDHOUSE SETTLEMENT REMAINS	161	135
10	EARLY SETTLEMENT REMAINS	452	310
11	BURIAL CAIRN	21	20
12	CLEARANCE CAIRN	1,081	131
13	ROUTEWAY	35	1
14	ROAD	21	10
15	LONG HOUSE	45	43
16	LONG CAIRN	1	1
17	FORT	2	2
18	BURNT MOUND	23	15
19	RIDGE AND FURROW	241	30
20	BARROW	4	4
21	CHAMBERED TOMB	3	3
22	STONE CIRCLE	4	4
23	CAIRNFIELD	80	80
24	CAIRN	54	22
	Total	10,253	2,060

Appendix K: Maps showing digitised features



Index map

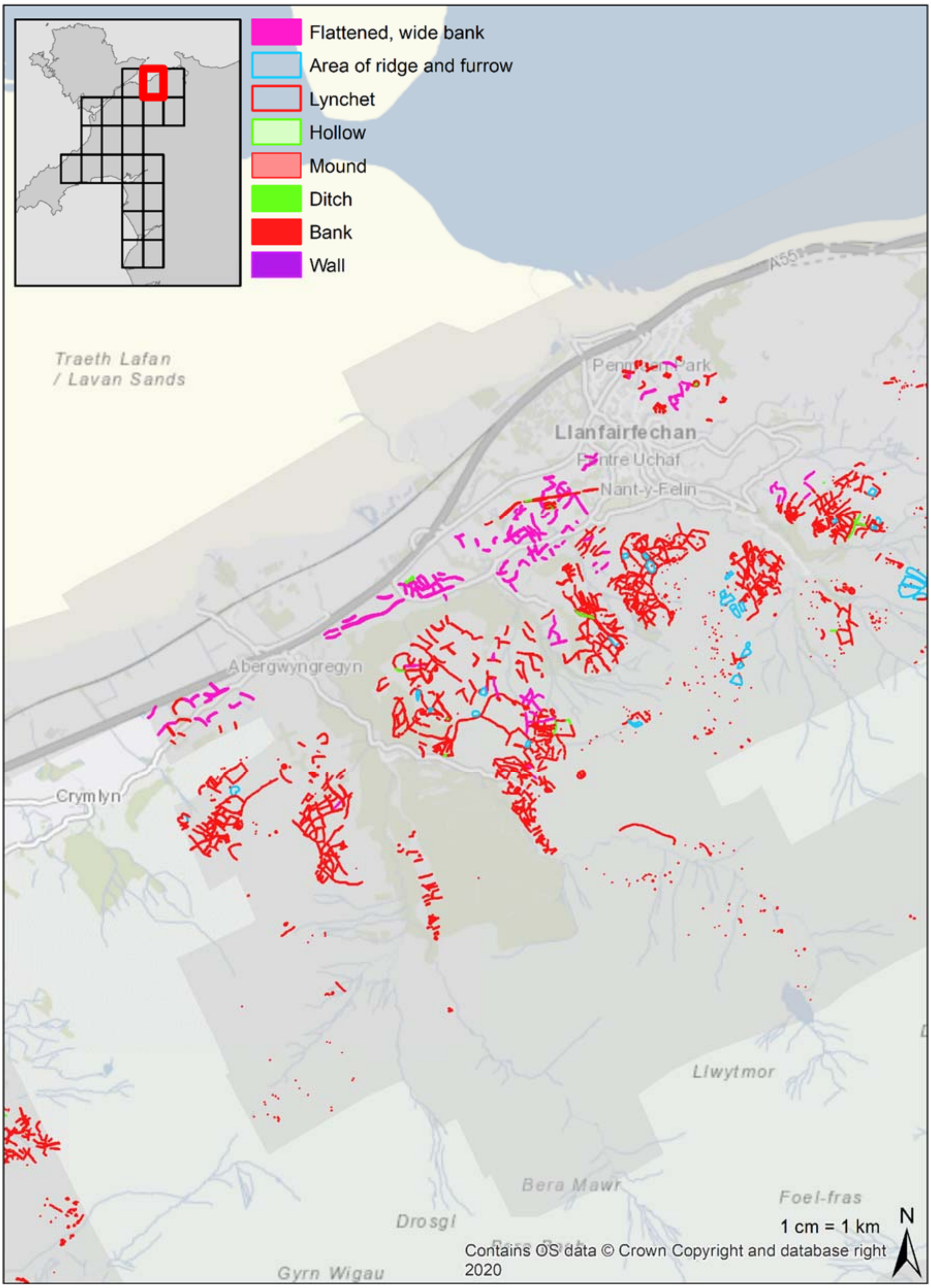
Numbered index refers to maps where features have been transcribed from lidar



Transcription map 1

Area south of Caerhun and Glasinfryn, and north of Llanllechid, shown at 1:50,000

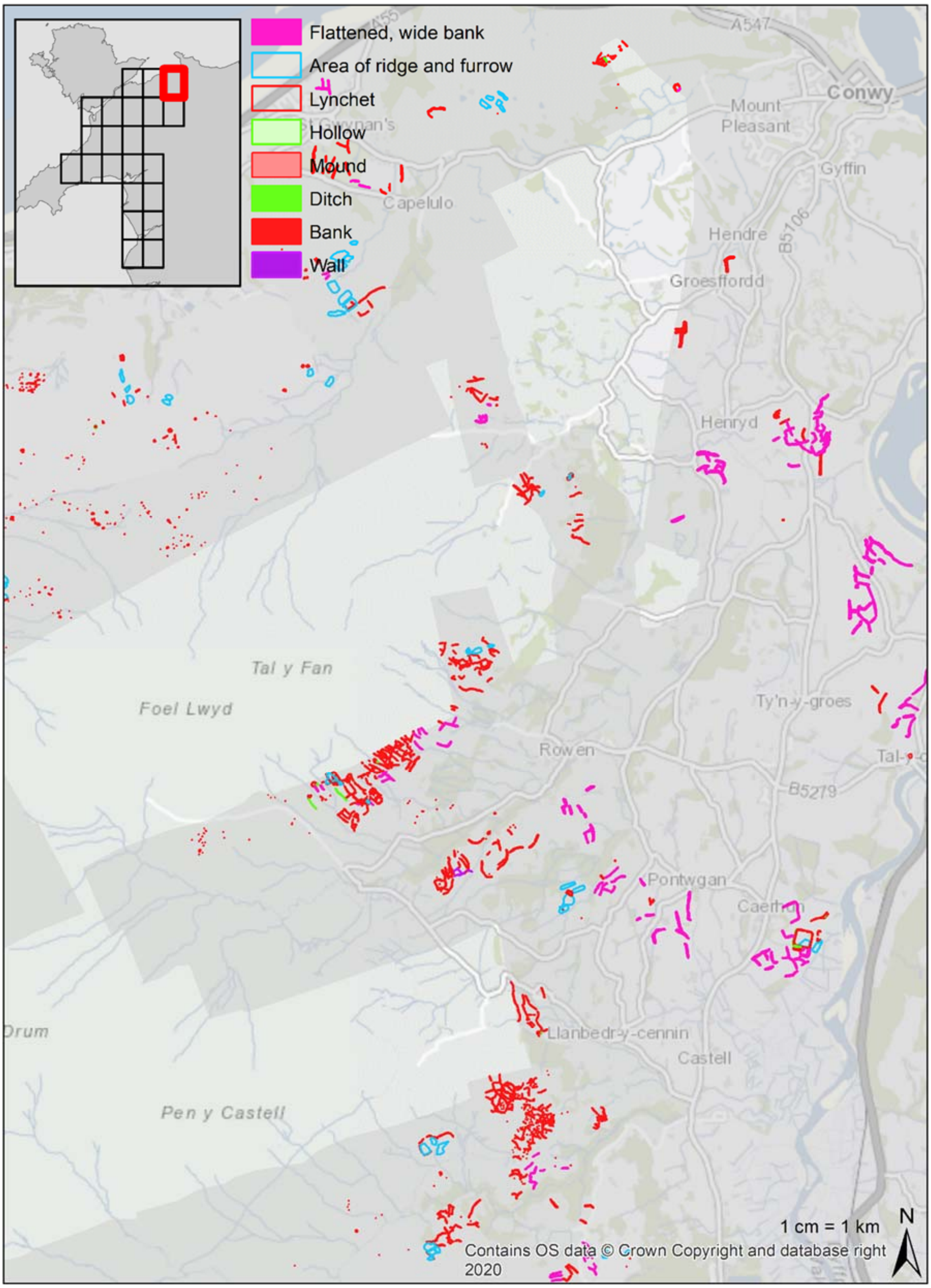
Significant new areas of ploughed-out earthwork banks were revealed on these mid-slopes.



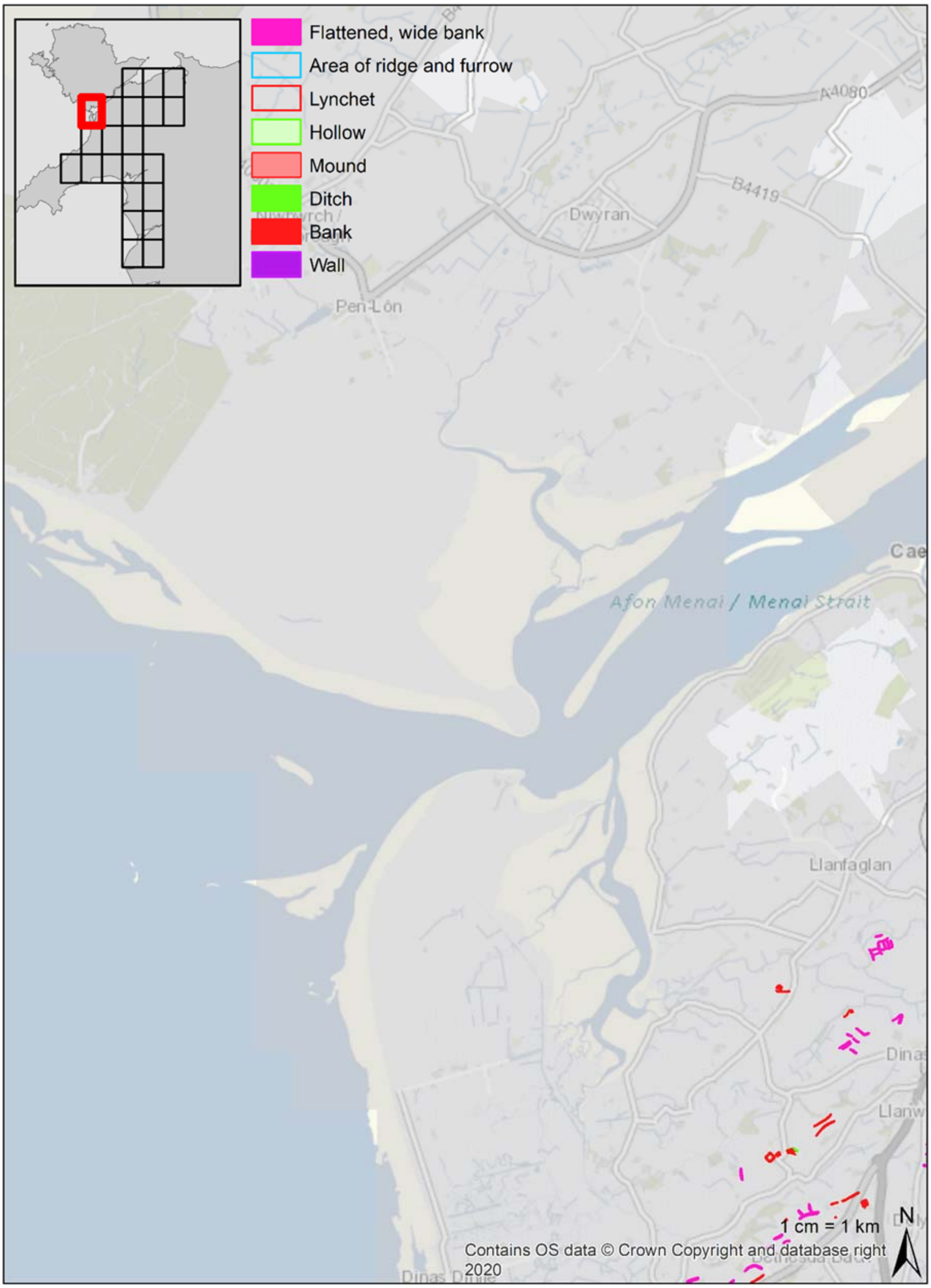
Transcription map 2

Uplands above Abergwyngregyn and Llanfairfechan, shown at 1:50,000

This area has good lidar coverage, where transcription revealed greater detail for known fieldscapes, along with the survival of ploughed-out earthwork banks on the coastal lowlands.



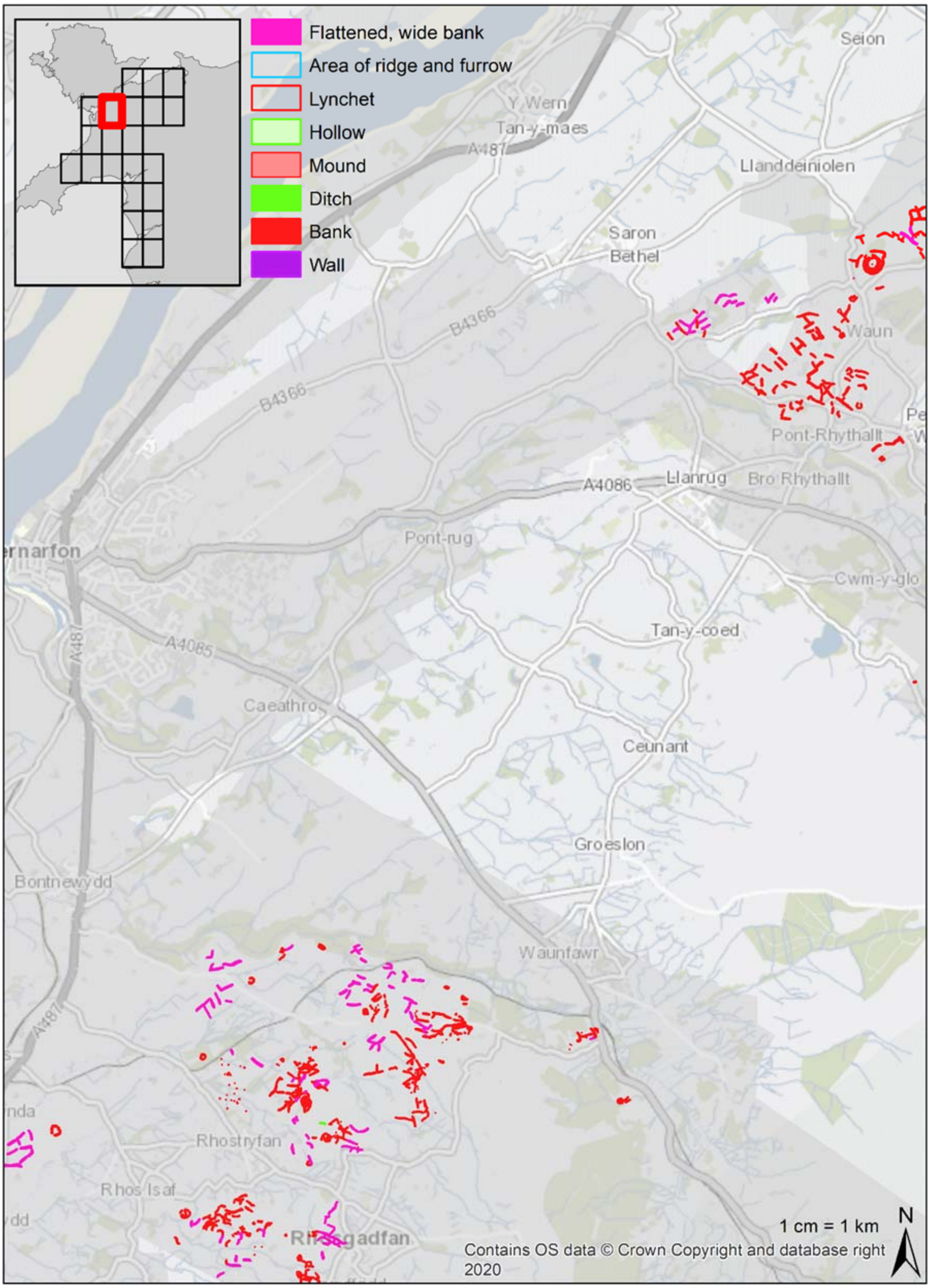
Transcription map 3:
Uplands on the western slopes of the Conwy river valley, above Llanbedr-y-Cennin and Rowen, shown at 1:50,000
The identification of early features can be seen to end abruptly below Tal y Fan, where there was no lidar coverage.



Transcription map 4

Low-lying coastal area to the south of Caernarfon, shown at 1:50,000

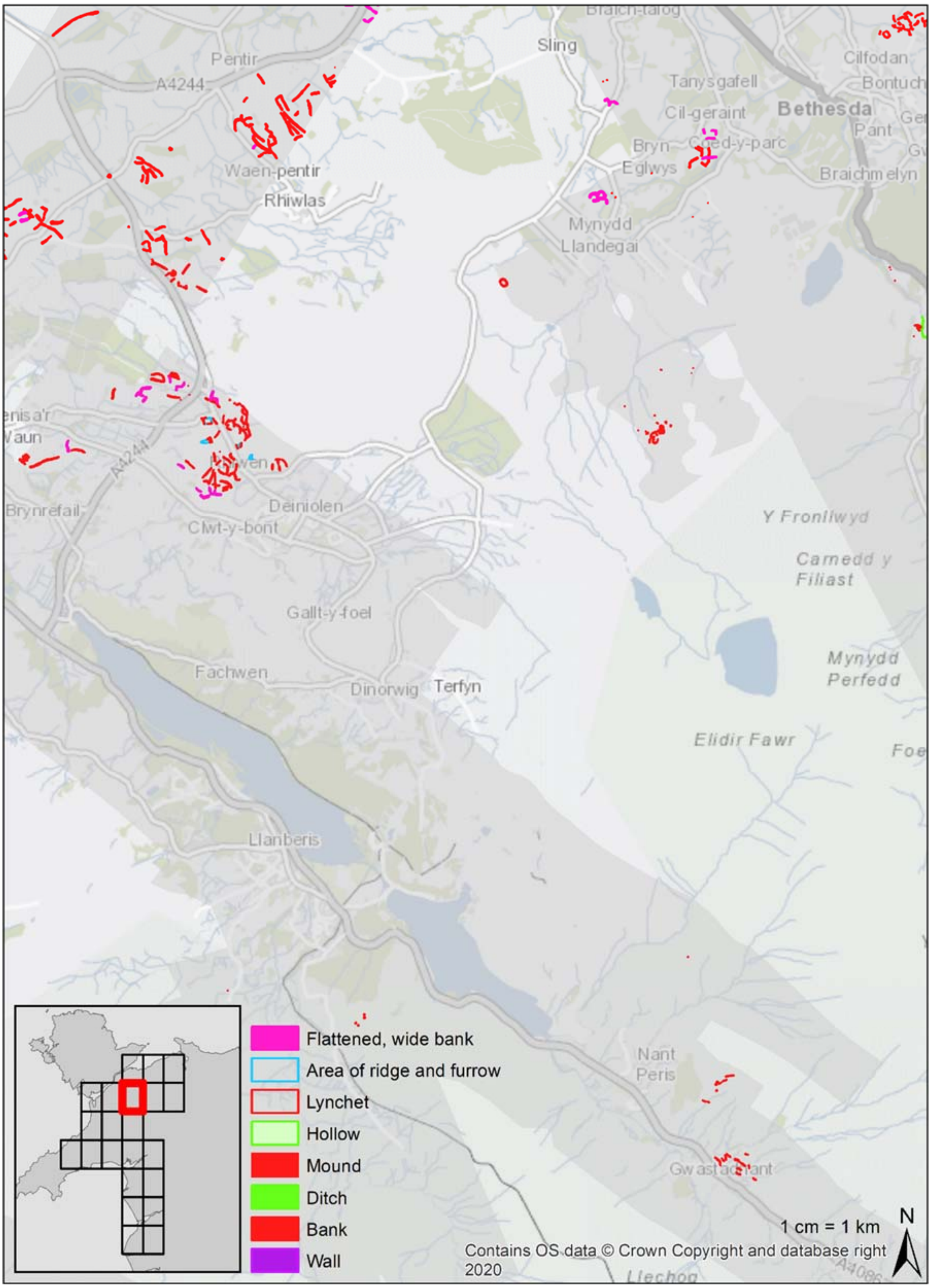
Extensive areas of drained and partially reclaimed land, and ancient braided watercourses made it more difficult to identify and transcribe early features.



Transcription map 5

Mid-slopes and uplands close to Llanrug, Rhostryfan and Rhosgadfan, shown at 1:50.000

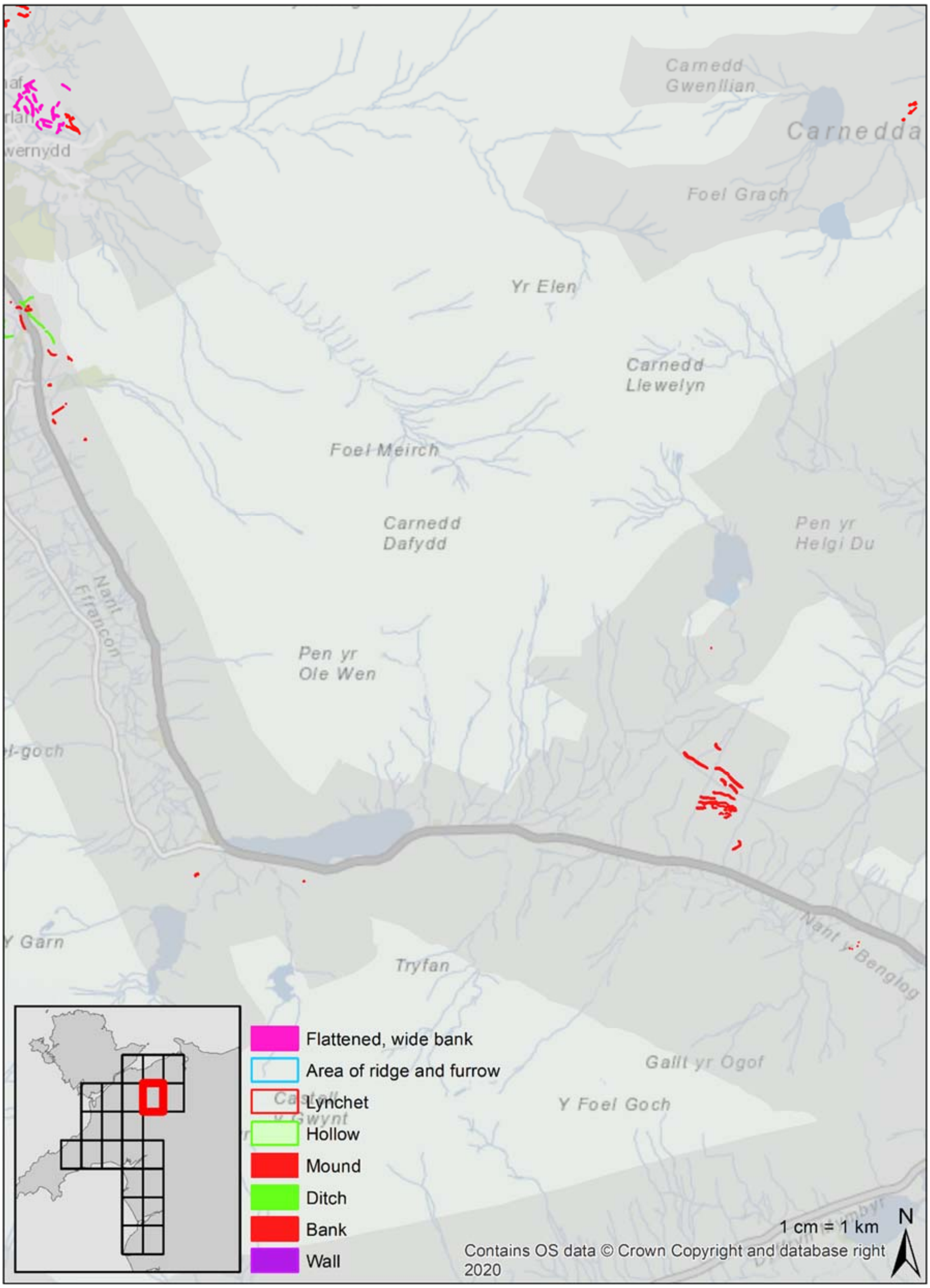
Although several known early fieldscapes were mapped in greater detail and extent, an important group of sites on land between Waunfawr and Cwm-y-glo could not be mapped because there is no lidar coverage for this area.



Transcription map 6

Llanberis, Brynrefail and Rhiwlas, shown at 1:50,000

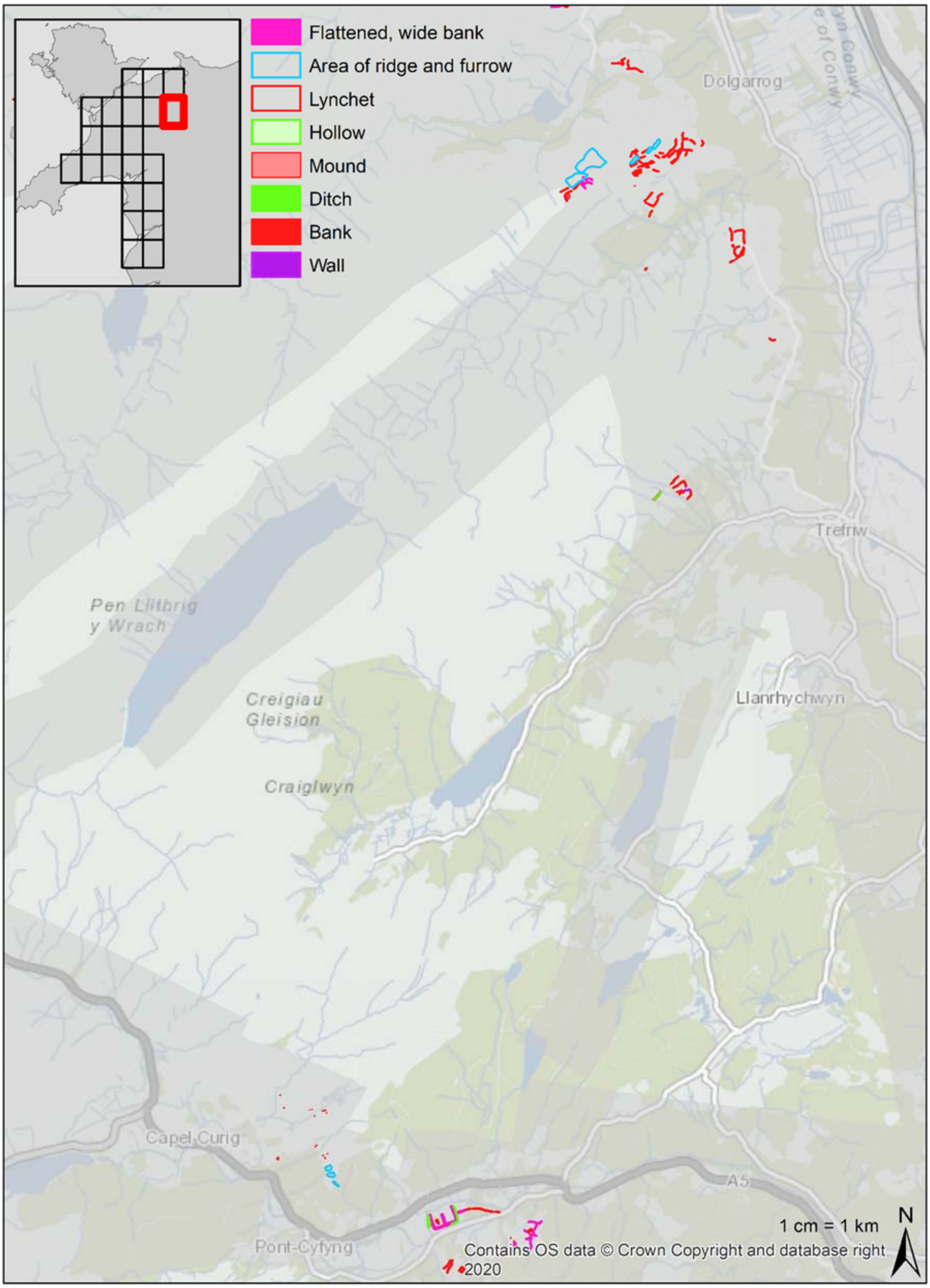
Although new features were transcribed in areas around Deiniolen and Pentir, the quality of lidar visualisations for steeper slopes south of Llanberis was poor and very few early fieldscape elements could be identified here.



Transcription map 7

Dyffryn Ogwen, shown at 1:50,000

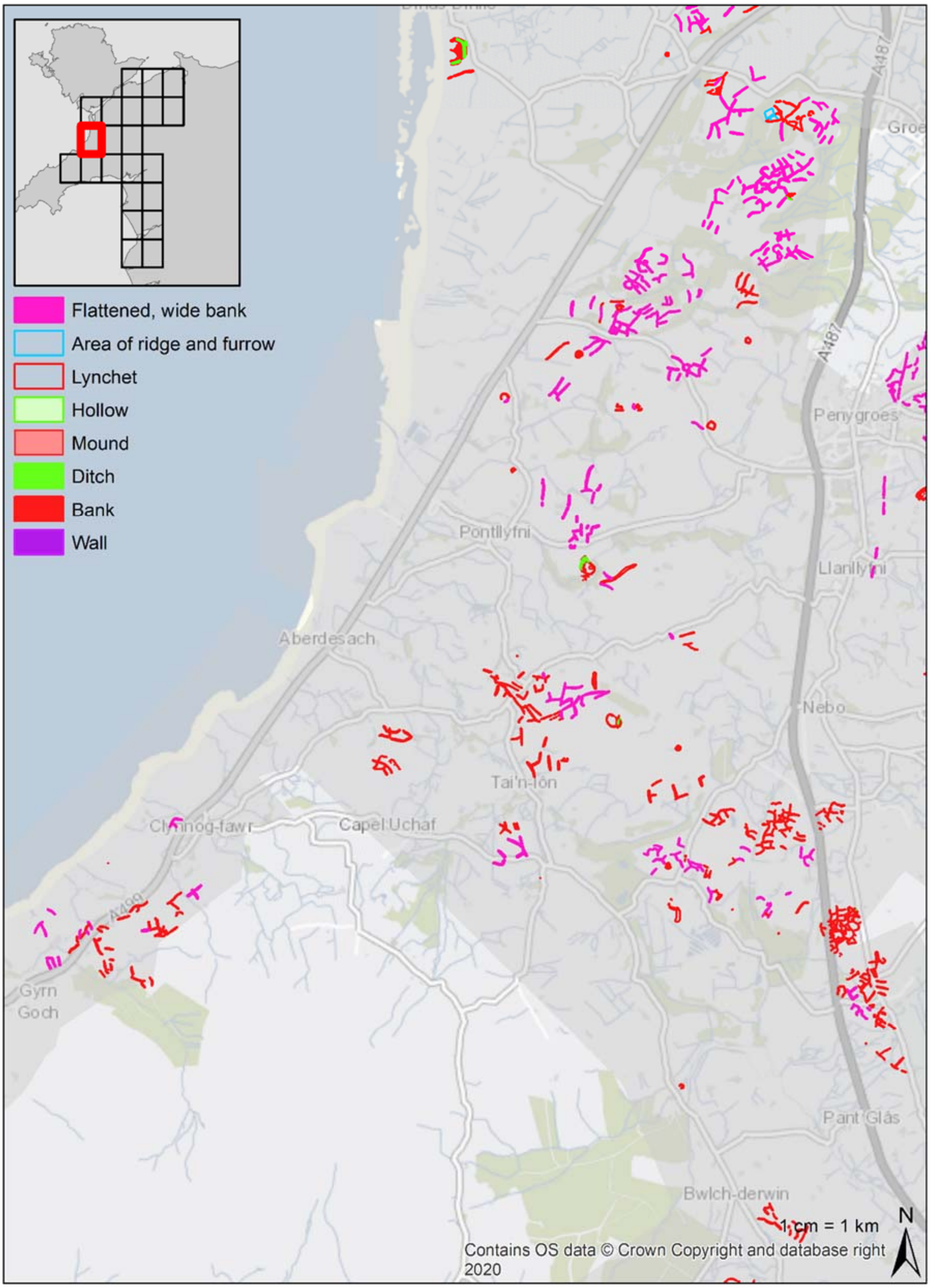
The quality of lidar visualisations for river valley along Nant y Benglog was poor and few features could be reliably transcribed.



Transcription map 8

Capel Curig and Trefriw, shown at 1:50,000

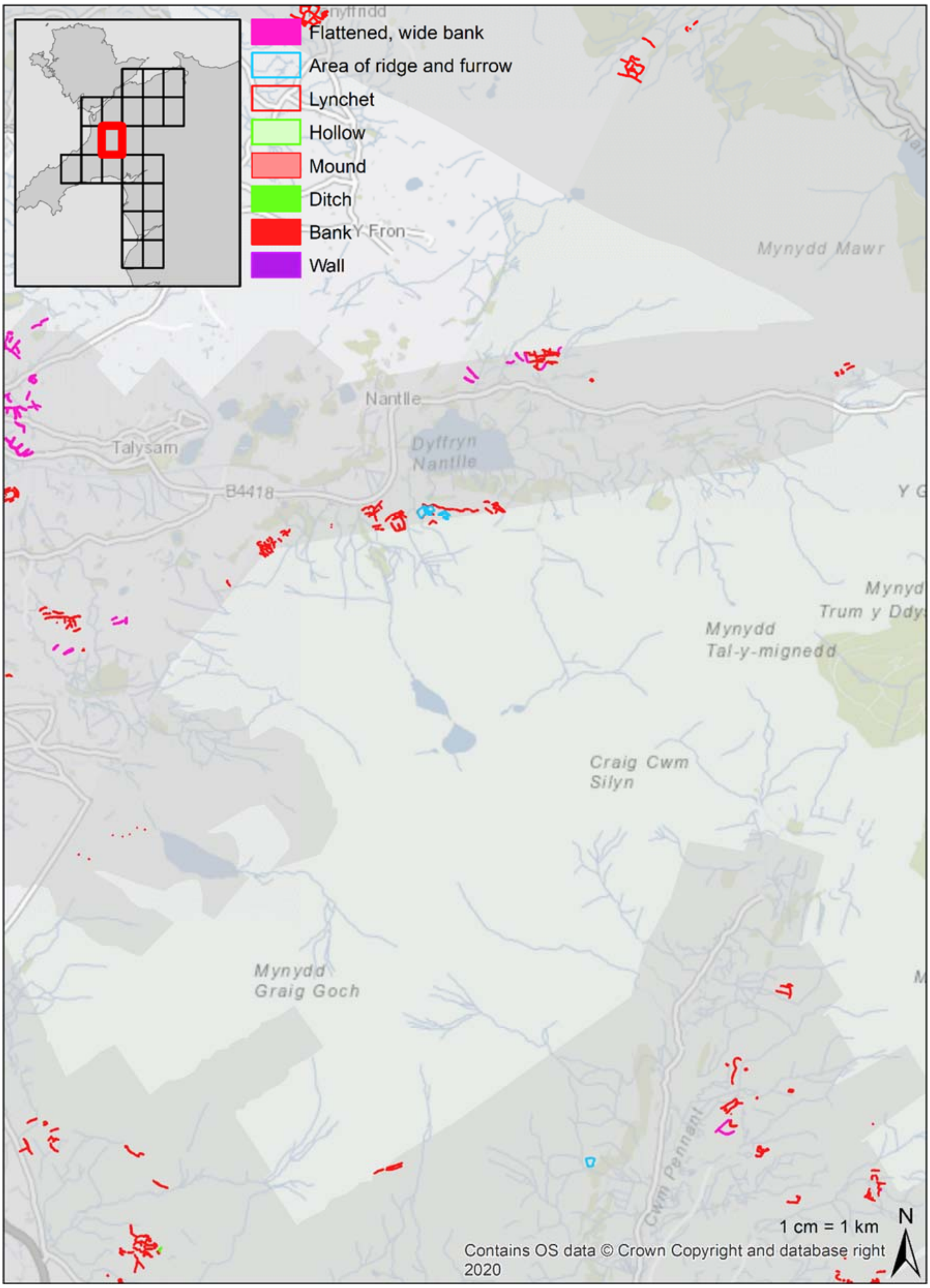
Features to the south and east of the Roman fort Bryn-y-Gefeliau (Caer Llugwy) reveal further information about its landscape context, but few other features were identified in the river valleys where lidar quality was poor.



Transcription map 9

Coastal strip south of Llandwrog, shown at 1:50,000

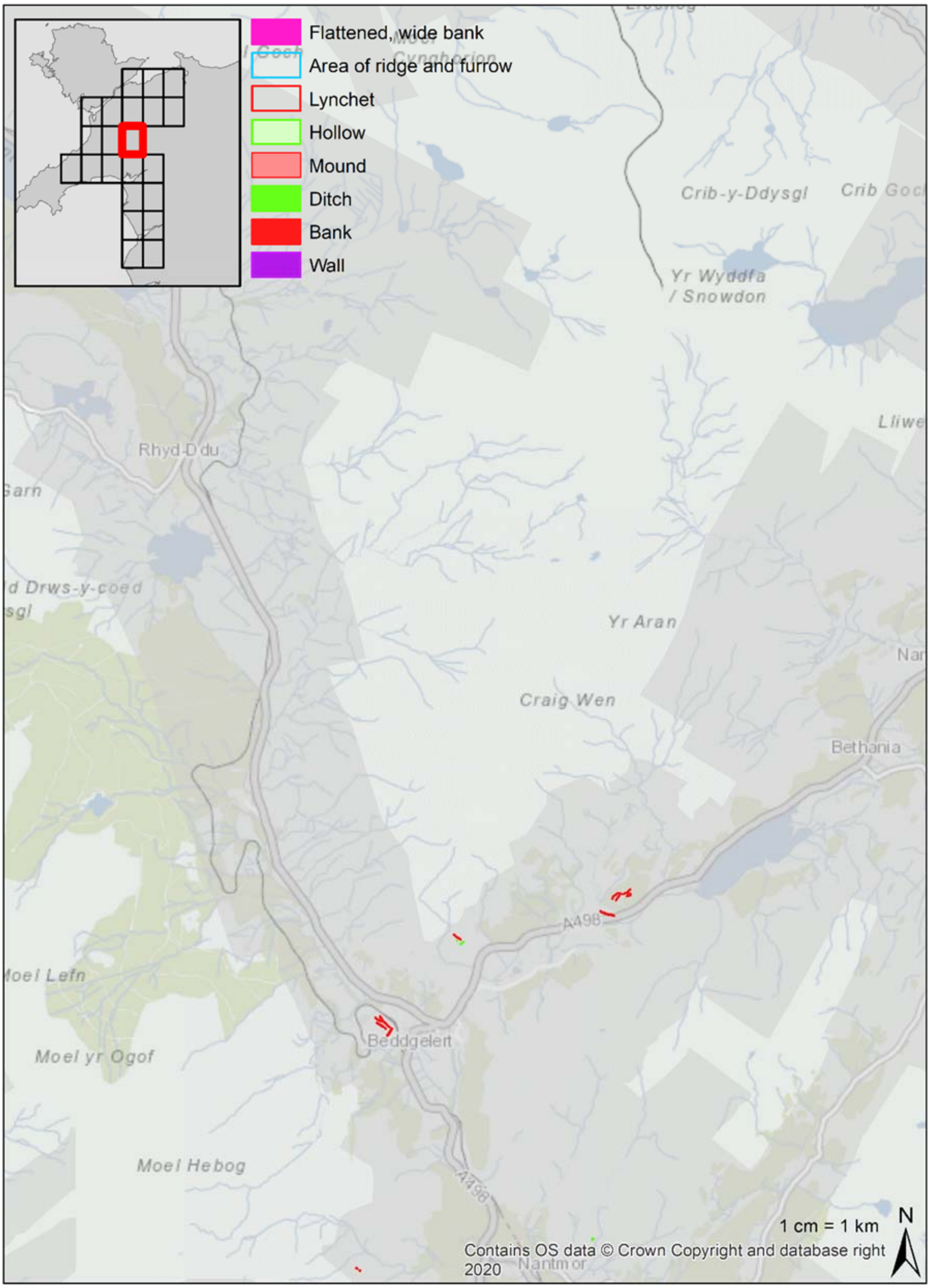
Extensive areas of new features were identified on lower-lying agricultural land within the parkland and estate of Glynllifon, and in areas further south.



Transcription map 10

Dyffryn Nantlle and Cwm Pennant, shown at 1:50,000

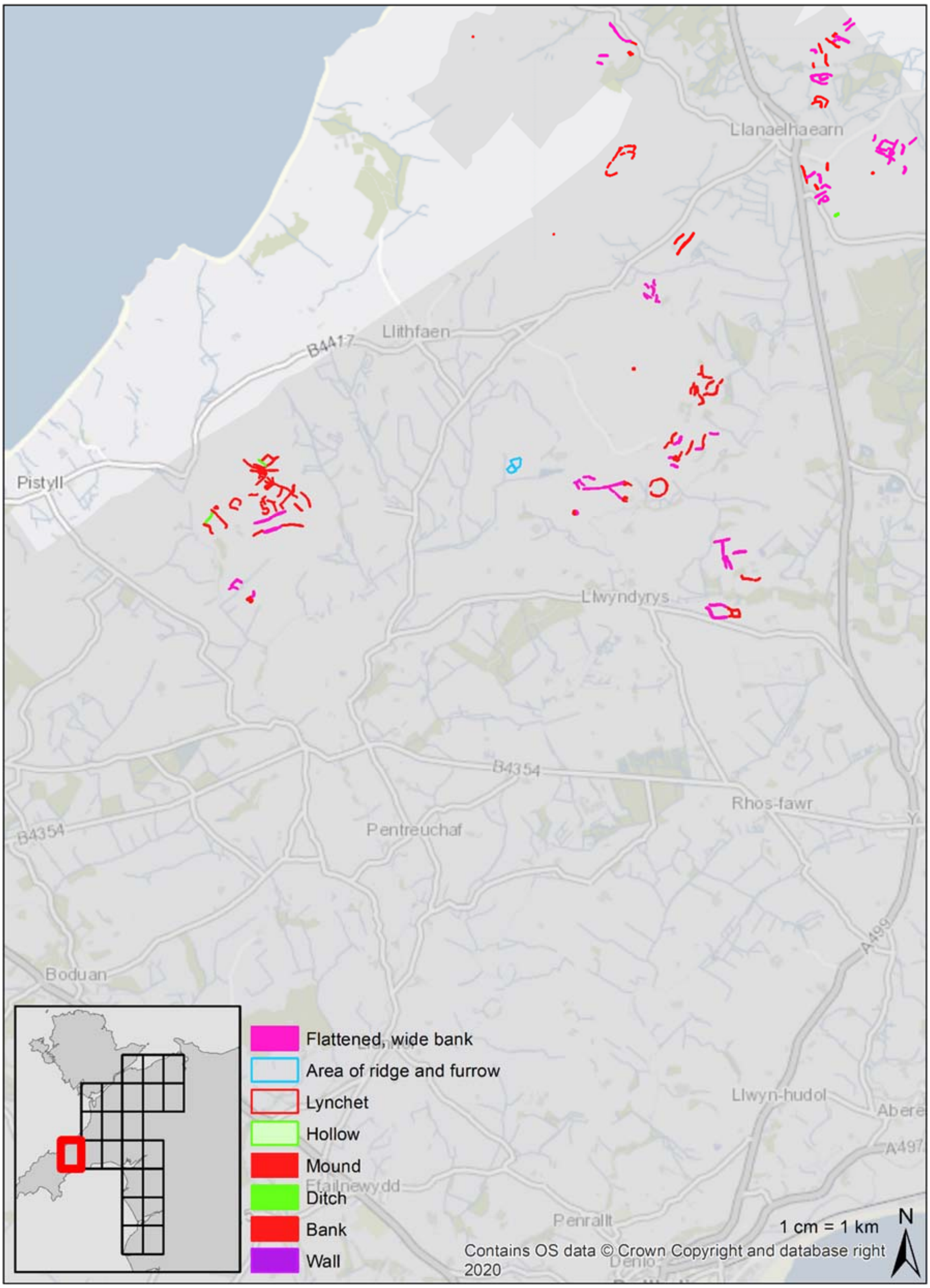
Most of the known early settlement remains and field systems lie outside the area with lidar coverage, but some new features were identified to the south of Talysarn.



Transcription map 11

Valleys between Rhyd-Ddu, Beddgelert and Glan Llyn, shown at 1:50,000

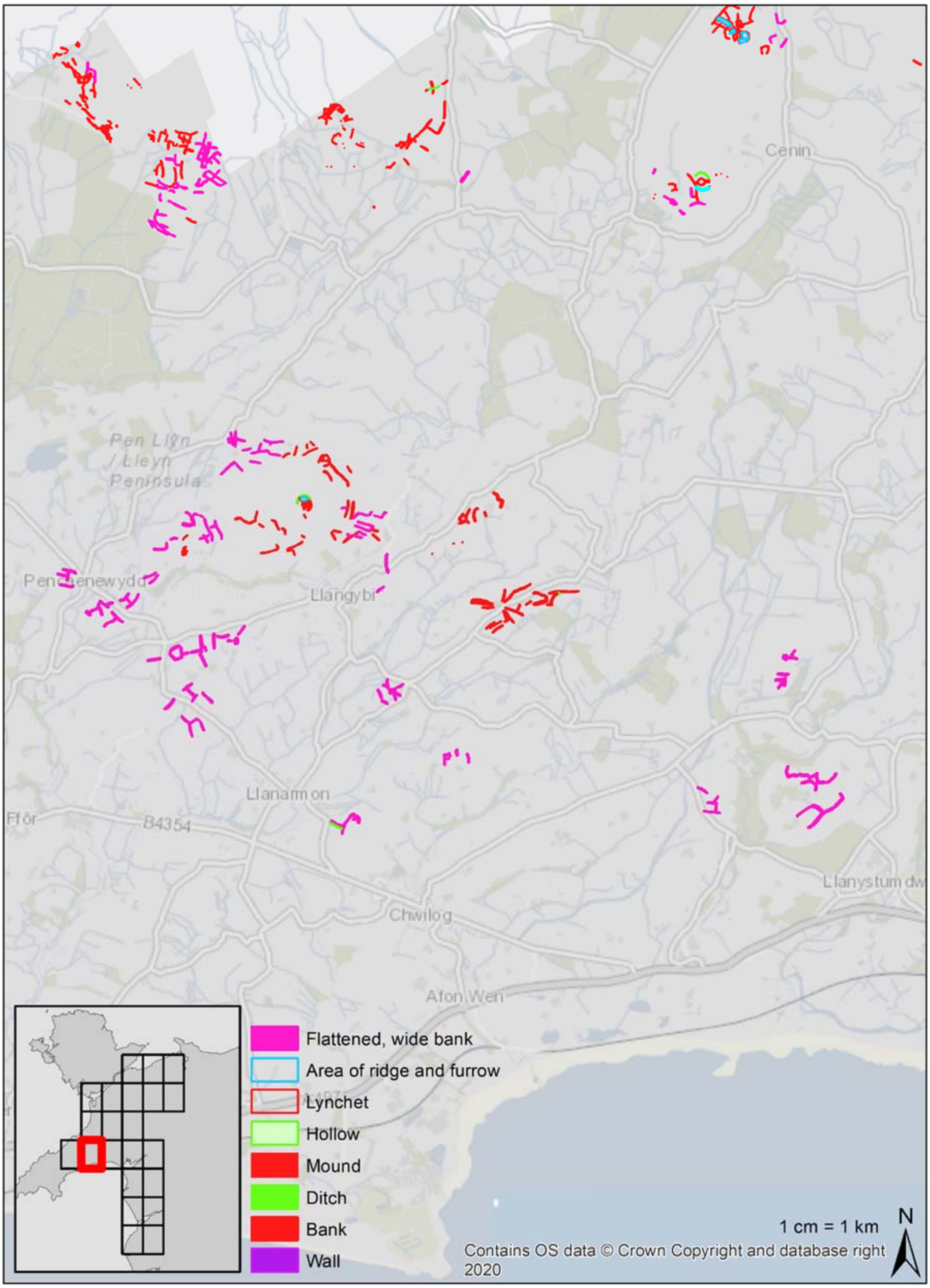
Only small numbers of features were identified from the lidar for these heavily wooded valleys, with limited lidar coverage on higher slopes where there are more known, previously recorded sites.



Transcription map 12

Llanaelhaearn and east Pen Llŷn, shown at 1:50,000

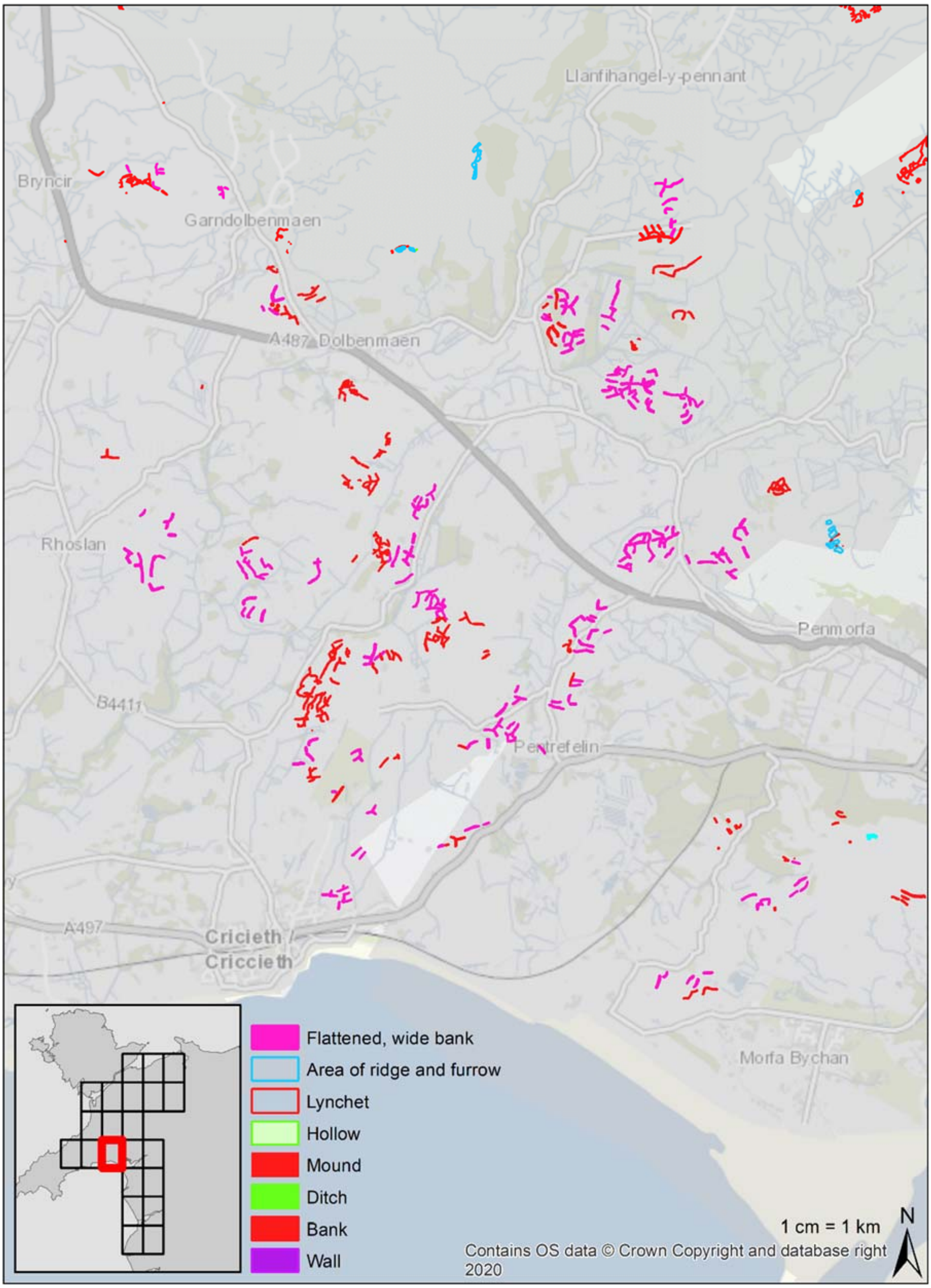
Field boundaries were mapped close or adjacent to several known early round house settlements.



Transcription map 13

North-east Pen Llŷn, shown at 1:50,000

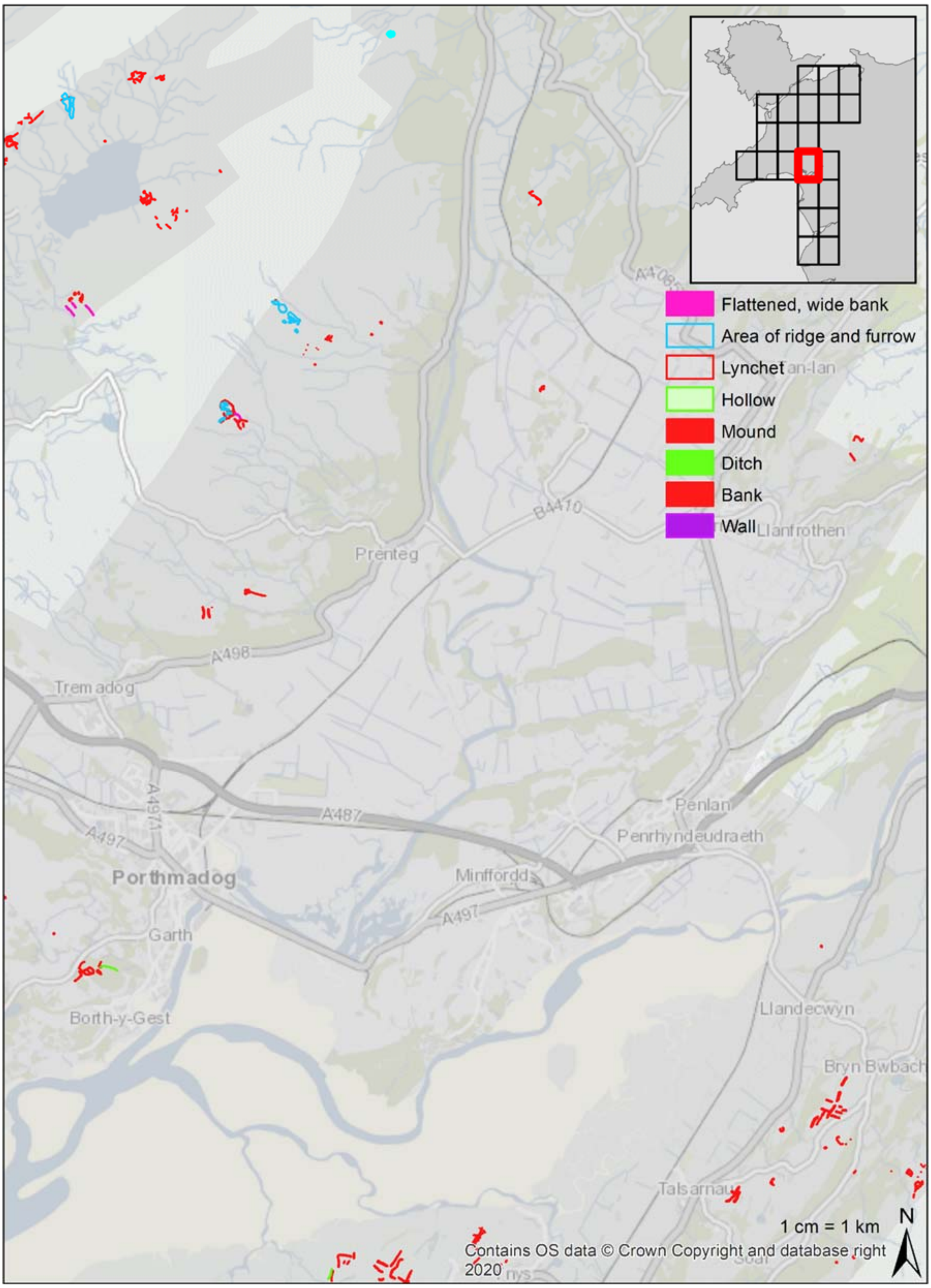
Extensive new areas of ploughed-out banks were identified on south-facing slopes.



Transcription map 14

Coastal lowlands north of Criccieth shown at 1:50,000

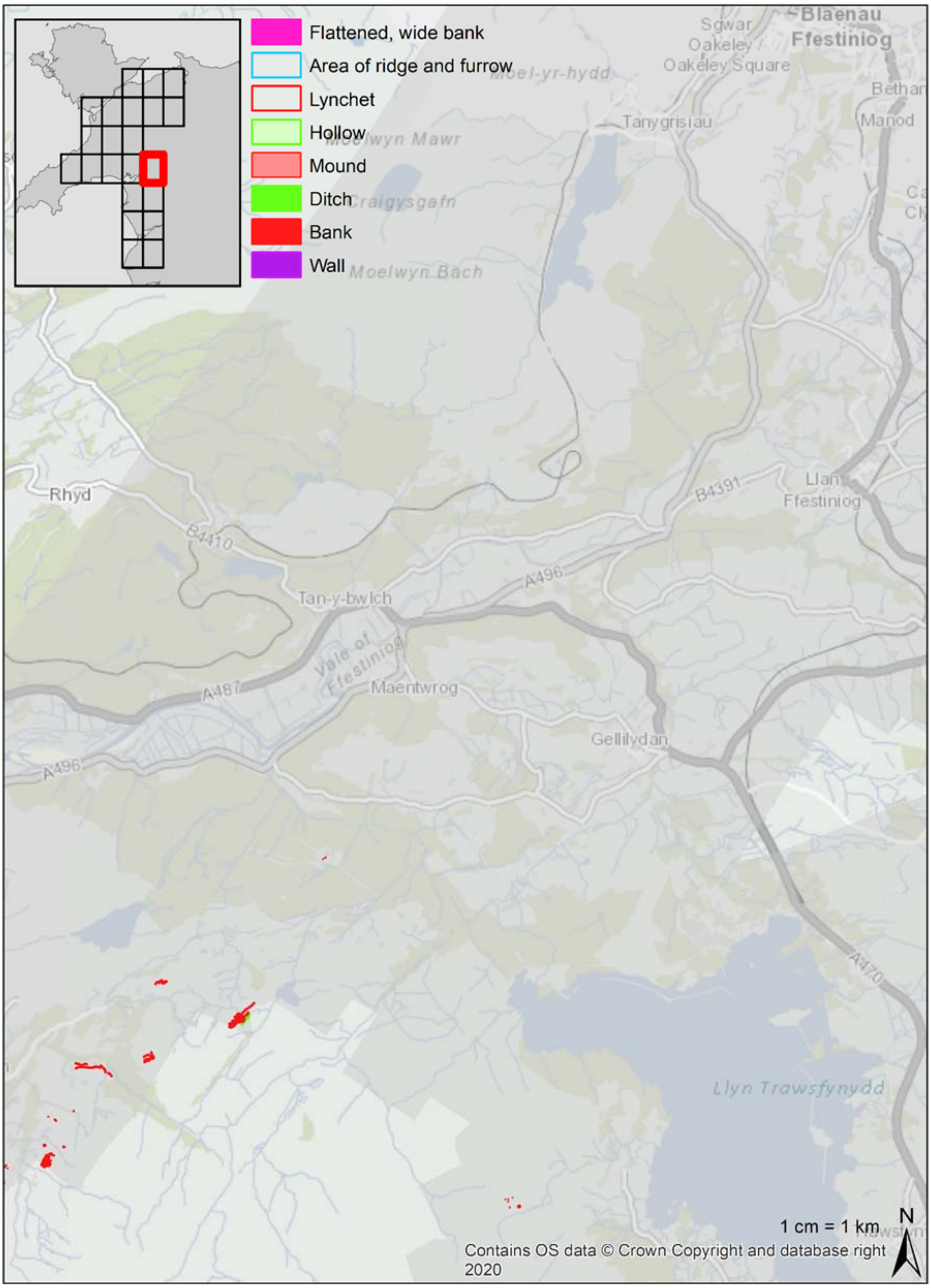
Greater detail and extent was revealed for known fieldscapes, along with new concentrations of features.



Transcription map 15

Porthmadog and Penrhyndeudraeth shown at 1:50,000

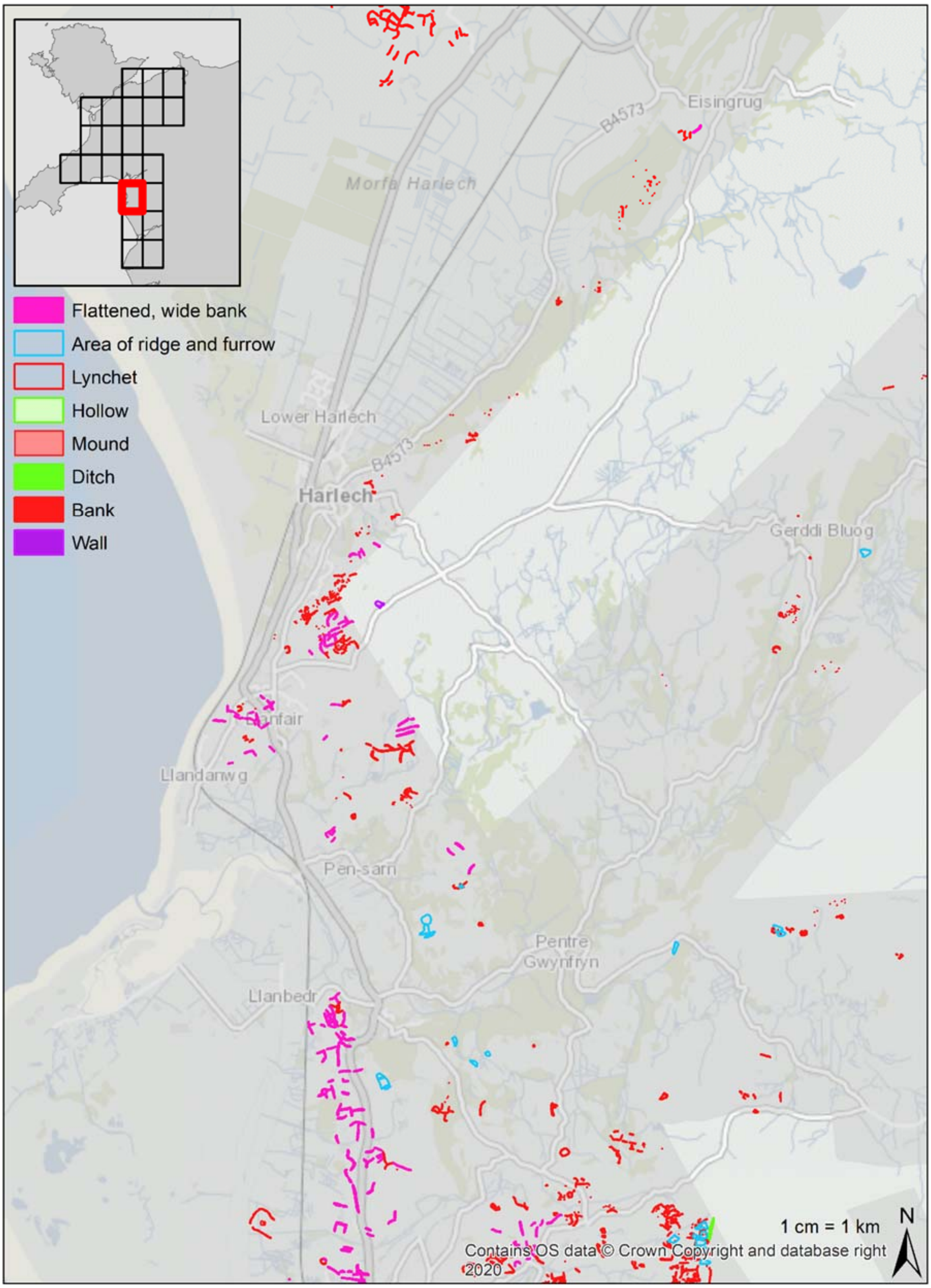
Scattered clusters of features were identified in this area, but unfortunately many of the known round house settlements and fields on Mynydd Gorllwyn are not located in areas where there was lidar coverage.



Transcription map 16

Area to the south of Maentwrog, shown at 1:50,000

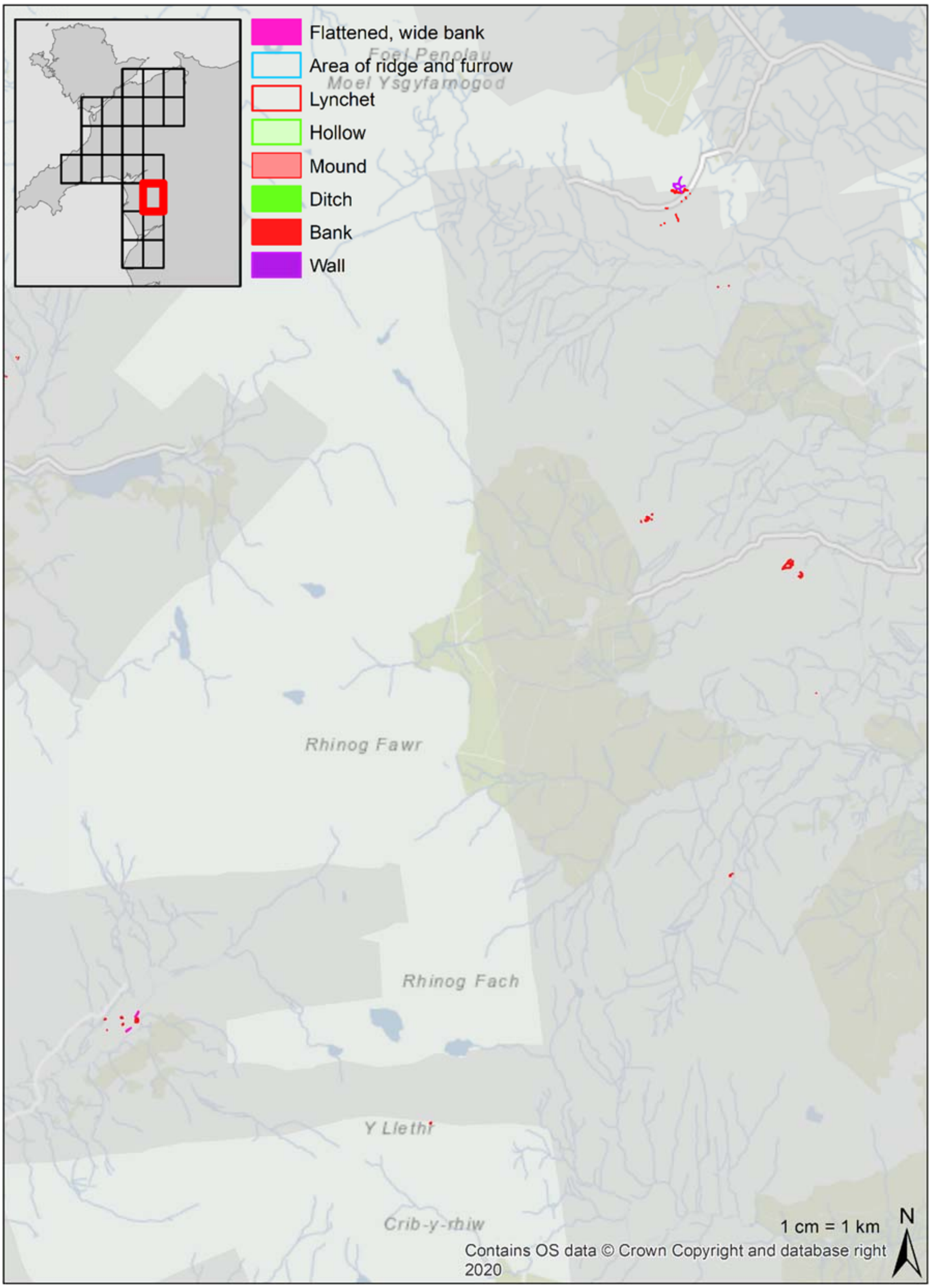
Clusters of features were found around several known settlement sites.



Transcription map 17

Areas to the north and south of Harlech, shown at 1:50,000

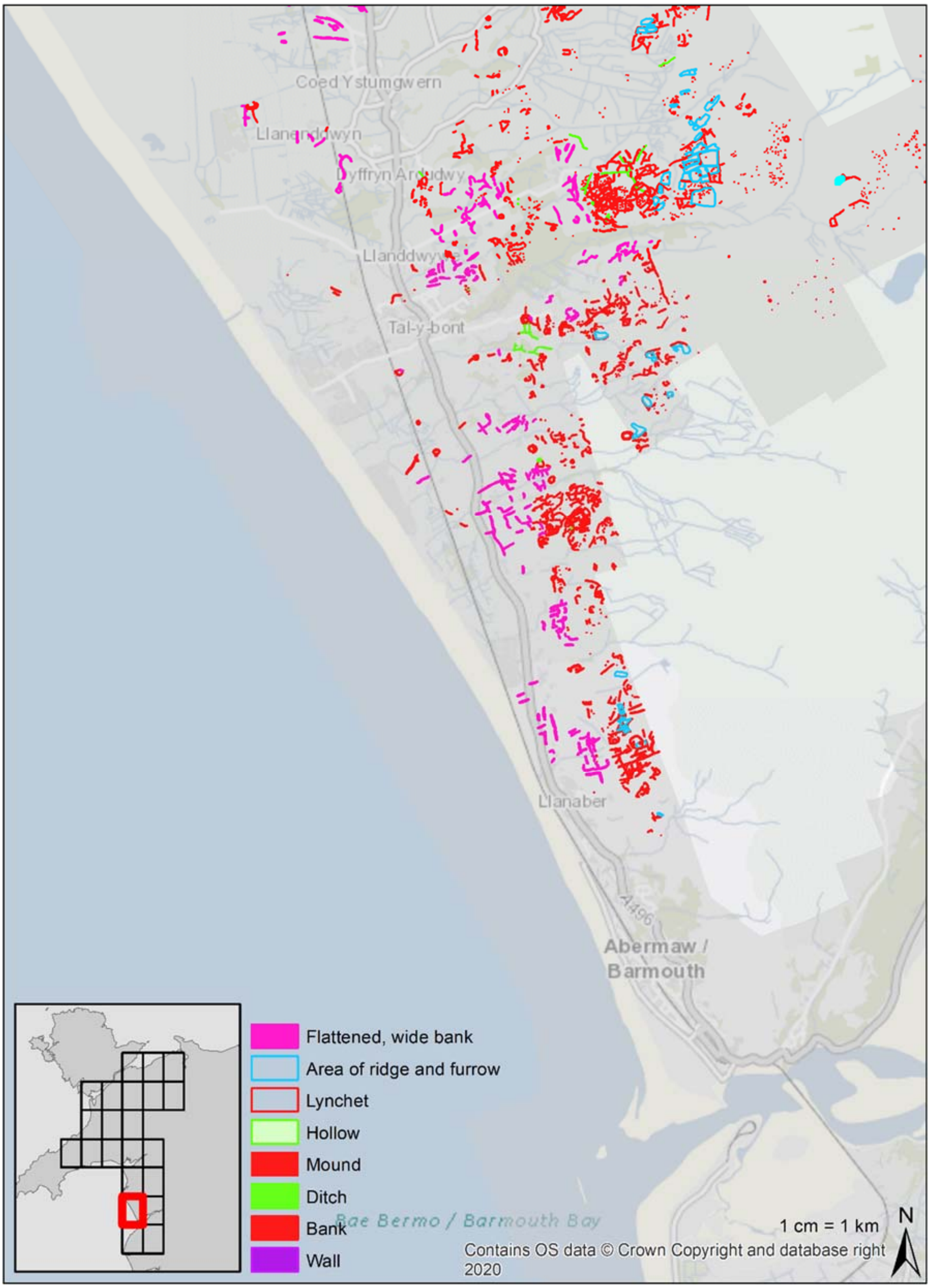
Many new features were identified on the lower slopes of Moel Goedog and the coastal lowlands.



Transcription map 18

Rhinogs shown at 1:50,000

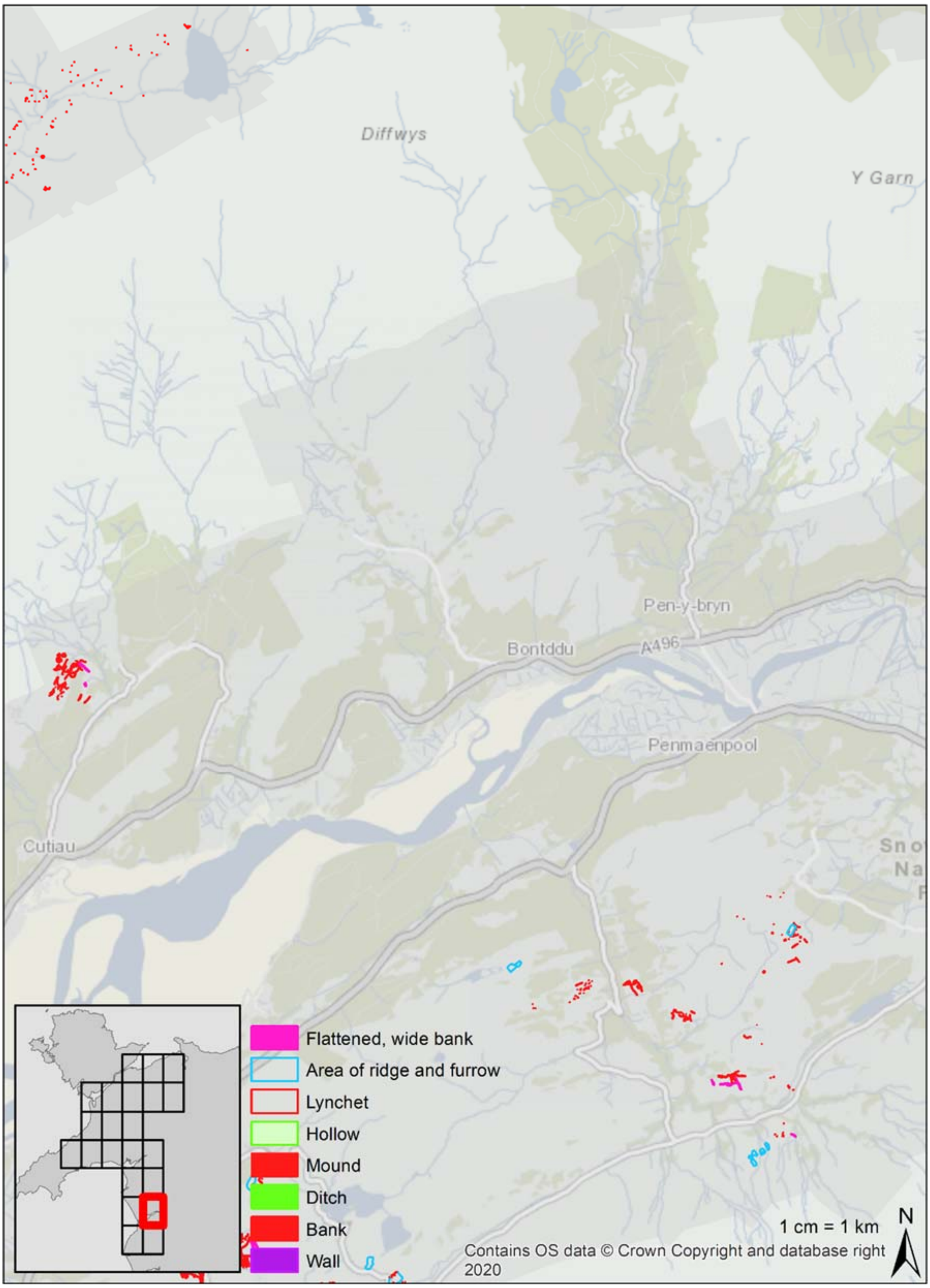
Poor quality lidar in this area led to very low numbers of transcribed features.



Transcription map 19

Coastal strip and mid-slopes between Harlech and Barmouth, shown at 1:50,000

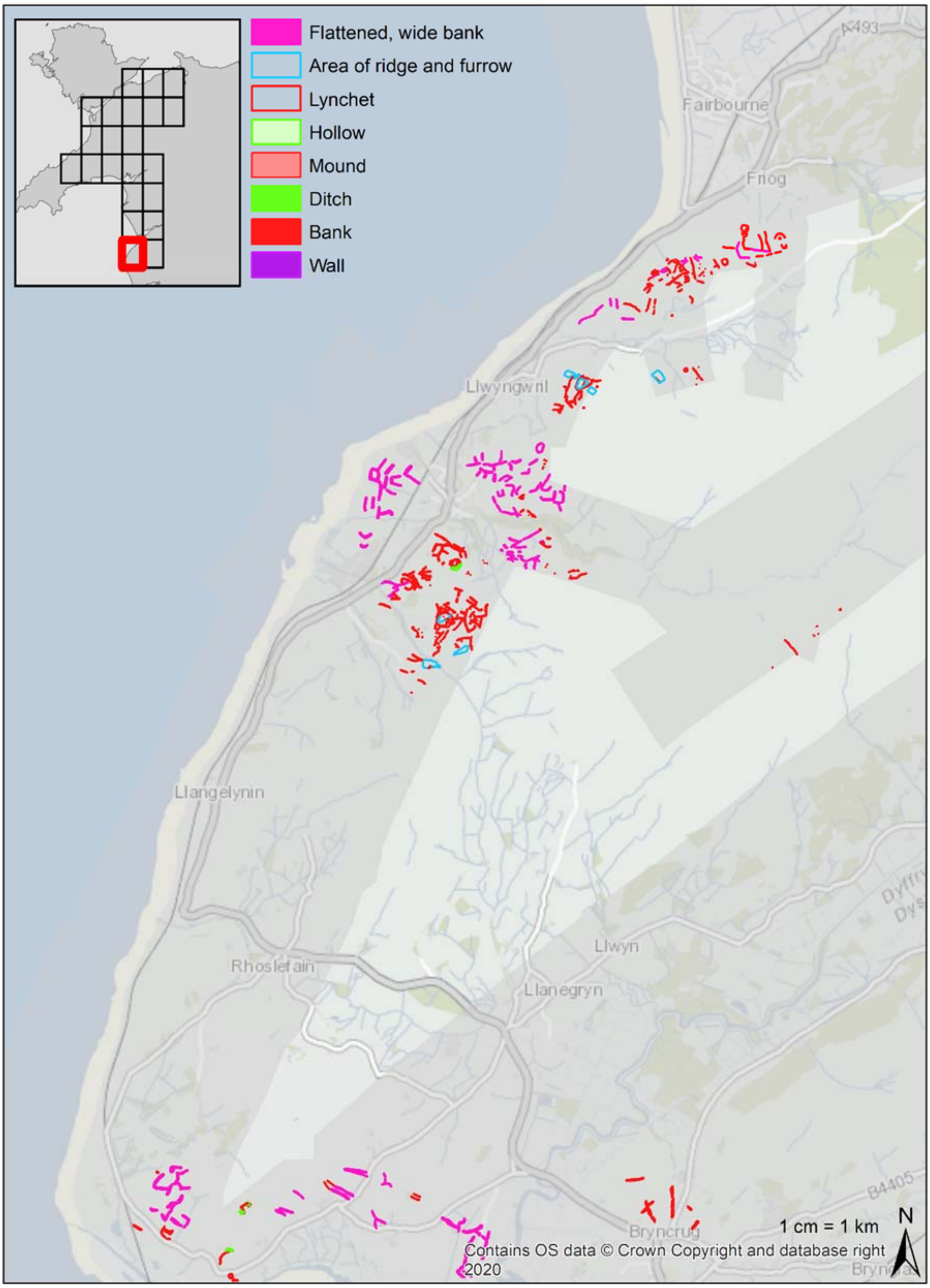
Feature transcription in this area significantly expanded the extent and detail of known sites, particularly on the lower western slopes.



Transcription map 20

Pen y Bryn and the northern slopes of Cadair Idris, shown at 1:50,000

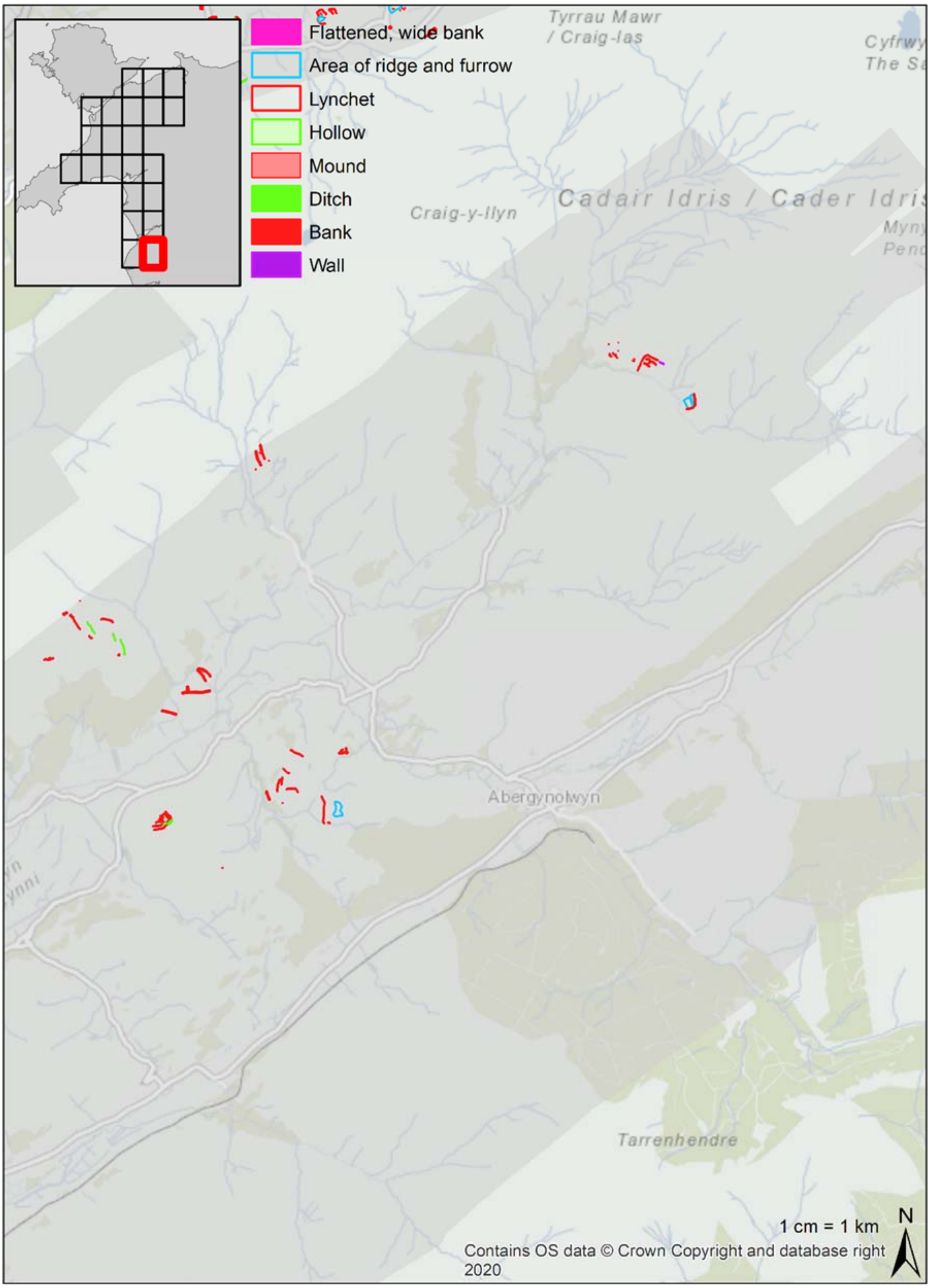
Although several clusters of features were transcribed in this area, many known early settlement sites and fields could not be identified from lidar visualisations.



Transcription map 21

Llwyngwril and Llangelynin shown at 1:50,000

The identification of several clusters of flattened, wide banks on lower-lying land expanded the extent of fieldscapes in an area where there are several known sites.



Transcription map 22

Southern slopes of Cadair Idris, shown at 1:50,000

Known field systems on the upper slopes of Cadair Idris could not be identified from lidar visualisations, but scattered boundaries were transcribed on its lower slopes.

Appendix L: New geospatial datasets

Table L1

Additional attribute fields generated through additional analysis for the transcription dataset

Field name	Number Format	Data Type	Allow NULL Values	Description
Trsp_Abs_Ele_MIN	Numeric	Double	No	Minimum absolute elevation (m)
Trsp_Abs_Ele_MAX	Numeric	Double	No	Maximum absolute elevation (m)
Trsp_Abs_Ele_RANGE	Numeric	Double	No	Range between the minimum and maximum absolute elevation (m)
Trsp_Abs_Ele_MEAN	Numeric	Double	No	Mean absolute elevation (m)
Trsp_Abs_Ele_STD	Numeric	Double	No	Standard deviation in values for absolute elevation
Trsp_Abs_Ele_SUM	Numeric	Double	No	Total (sum) of all values for absolute elevation
Trsp_Rel_Ele_MIN	Numeric	Double	No	Minimum relative elevation (m)
Trsp_Rel_Ele_MAX	Numeric	Double	No	Maximum relative elevation (m)
Trsp_Rel_Ele_RANGE	Numeric	Double	No	Range between the minimum and maximum relative elevation (m)
Trsp_Rel_Ele_MEAN	Numeric	Double	No	Mean relative elevation (m)
Trsp_Rel_Ele_STD	Numeric	Double	No	Standard deviation in values for relative elevation
Trsp_Rel_Ele_SUM	Numeric	Double	No	Total (sum) of all values for relative elevation
Trsp_Slope_MIN	Numeric	Double	No	Minimum slope value (m)
Trsp_Slope_MAX	Numeric	Double	No	Maximum slope value (m)
Trsp_Slope_RANGE	Numeric	Double	No	Range between the minimum and maximum slope value (m)
Trsp_Slope_MEAN	Numeric	Double	No	Mean slope value (m)
Trsp_Slope_STD	Numeric	Double	No	Standard deviation in values for slope value
Trsp_Slope_SUM	Numeric	Double	No	Total (sum) of all values for slope value

Table L2

Additional attribute fields generated through additional analysis for the research categorisation dataset

Field name	Number Format	Data Type	Allow NULL Values	Description
ResCat_Abs_Ele_MIN	Numeric	Double	No	Minimum absolute elevation (m)
ResCat_Abs_Ele_MAX	Numeric	Double	No	Maximum absolute elevation (m)
ResCat_Abs_Ele_RANGE	Numeric	Double	No	Range between the minimum and maximum absolute elevation (m)
ResCat_Abs_Ele_MEAN	Numeric	Double	No	Mean absolute elevation (m)
ResCat_Abs_Ele_STD	Numeric	Double	No	Standard deviation in values for absolute elevation
ResCat_Abs_Ele_SUM	Numeric	Double	No	Total (sum) of all values for absolute elevation
ResCat_Rel_Ele_MIN	Numeric	Double	No	Minimum relative elevation (m)
ResCat_Rel_Ele_MAX	Numeric	Double	No	Maximum relative elevation (m)
ResCat_Rel_Ele_RANGE	Numeric	Double	No	Range between the minimum and maximum relative elevation (m)
ResCat_Rel_Ele_MEAN	Numeric	Double	No	Mean relative elevation (m)
ResCat_Rel_Ele_STD	Numeric	Double	No	Standard deviation in values for relative elevation
ResCat_Rel_Ele_SUM	Numeric	Double	No	Total (sum) of all values for relative elevation
ResCat_Slope_MIN	Numeric	Double	No	Minimum slope value (m)
ResCat_Slope_MAX	Numeric	Double	No	Maximum slope value (m)
ResCat_Slope_RANGE	Numeric	Double	No	Range between the minimum and maximum slope value (m)
ResCat_Slope_MEAN	Numeric	Double	No	Mean slope value (m)
ResCat_Slope_STD	Numeric	Double	No	Standard deviation in values for slope value
ResCat_Slope_SUM	Numeric	Double	No	Total (sum) of all values for slope value

Table L3

Supplementary new geospatial datasets generated through additional analysis

GIS resource description	Description, including data type, geometry type and lineage	Layer title(s)
Upper tier grouping analysis datasets	Kernel density plot defining 13 upper tier groups defined through Grouping Analysis • Data type: File System Raster • Format: GRID	kernel_all
	Feature density contours defining 13 upper tier groups defined through Grouping Analysis • Data type: Shapefile Feature Class • Geometry type: line	Contour_0_05
	Seed points for 13 upper tier groups defined through Grouping Analysis • Data type: Shapefile Feature Class • Geometry type: point	Grouping_13
Second tier grouping analysis datasets	Kernel density plot defined through Grouping Analysis to identify second tier groups for each of the 13 upper tier groups • Data type: File System Raster • Format: TIFF	Multiple layers using the following format, where 00 represents a grouping number (e.g. group 1): RC00_KernelID
	Feature density contours identify second tier groups for each of the 13 upper tier groups based on kernel density plot. • Data type: Shapefile Feature Class • Geometry type: line	Multiple layers using the following format, where 00 represents a grouping number (e.g. group 1): RC00_contour_0_05
	Second tier seed points defined to identify second tier groups for each of the 13 upper tier groups • Data type: Shapefile Feature Class • Geometry type: point	Multiple layers using the following format, where 00 represents a grouping number (e.g. group 1): RC00_Grouping_Final

Enclosure grouping analysis datasets	Kernel density plot defining 6 enclosure groups defined through Grouping Analysis • Data type: File System Raster • Format: TIFF	All_enc_den
	Feature density contours defining 6 upper tier groups defined through Grouping Analysis • Data type: Shapefile Feature Class • Geometry type: line	Enclosure_contour
	Seed points for 6 upper tier groups defined through Grouping Analysis • Data type: Shapefile Feature Class • Geometry type: point	RCEnclosure_w_Groupings
Centreline datasets	Centre line for all linear features in the transcription dataset, comprising banks, flattened wide banks, scree banks, ditches and lynchets. • Data type: Shapefile Feature Class • Geometry type: line	COMBINEDandEDITEDlinears
	Minimum bounding circle for the COMBINEDandEDITEDlinears dataset. • Data type: Shapefile Feature Class • Geometry type: polygon	MinBOUNDINGfinal