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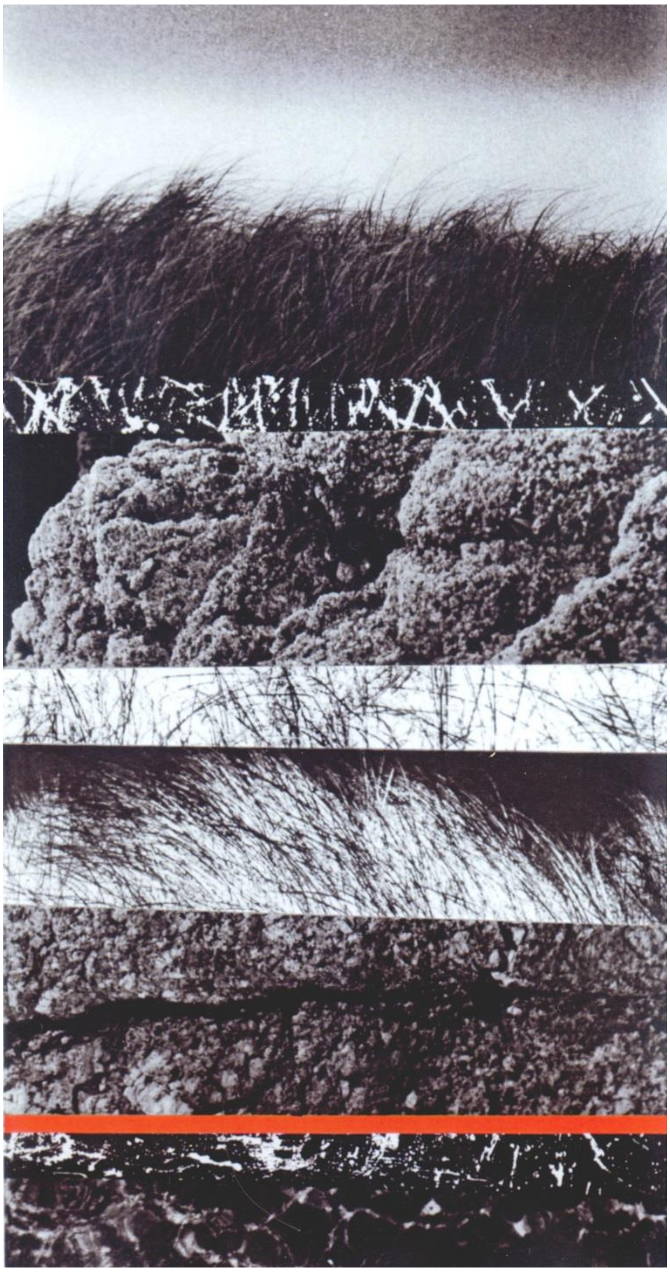
Lowland Cornwall: the hidden landscape. 5643. Volume 5

Overview



Cornwall Archaeological Unit

Lowland Cornwall: the hidden landscape 5643. Volume 5

Overview

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Abbreviations

CAU	Cornwall Archaeological Unit
EH	English Heritage
HE	Historic England
HER	Historic Environment Record
HLC	Historic Landscape Characterisation
NGR	National Grid Reference
NMP	National Mapping Programme
OD	Ordnance Datum – height above mean sea level at Newlyn
OS	Ordnance Survey
PAS	Portable Antiquities Scheme
SMR	Sites and Monuments Record

1 Summary

1.1 Background

Cornwall's lowland areas probably have the highest archaeological potential in the county to contain buried archaeological features, but are poorly understood and increasingly subject to the impacts of major change in land use and development. The Lowland Cornwall project attempts to address this issue by developing a method for predictive modelling of the lowland prehistoric and Romano-British landscape. The project methodology offers a foundation for informing future management and land use decisions in Cornwall, but the approach has much wider application, highlighting the potential to be realised from a consideration of Historic Landscape Characterisation (HLC) alongside other historic environment datasets, and it has the potential for application in other parts of the country.

The project consisted of four stages:

- preparation of datasets and high level predictive models
- deepening or refinement of HLC
- further analysis of the archaeological resource and the preparation of predictive models using the refined HLC
- presentation of final results

This is the fifth of five volumes reporting on the project and it presents an overview of the results from each stage.

1.2 Historic Landscape Characterisation

HLC aims to identify, describe, interpret and map the main historic influences which have shaped and defined the present day landscape. It is a GIS-based technique using polygons which reflect common historic characteristics. Each polygon is assigned to one of a pre-defined set of broad high-level HLC classes such as 'Ornamental' or 'Woodland'. In Cornwall's HLC these high-level definitions are termed HLC Zones. These are further characterised to produce a set of HLC Types, such as 'Deer park' or 'Ancient woodland', reflecting visible extant historic character.

Cornwall's HLC was developed in 1994 and has for some years been used as a predictive tool for justifying planning conditions for development proposals, most notably in areas characterised by the Types Farmland Medieval and Farmland Prehistoric (that is enclosed land that fossilises the medieval or prehistoric field patterns) which are considered to have high archaeological potential. This is particularly the case for settlement sites, leading to the proposition that the zone of medieval settlement was also the zone for prehistoric and Romano-British settlement. The Lowland Cornwall project attempts to test this existing model and to develop a statistical method for predictive modelling of the lowland prehistoric and Romano-British landscape. A further aim of the project is to refine or deepen Cornwall's existing HLC by further subdividing the Types into a series of Sub-Types in order to explore the possibility that some forms of Farmland Medieval and Farmland Prehistoric have higher archaeological potential than others.

1.3 Methodology

Lowland Cornwall is defined as those areas of the county which are predominantly actively farmed, consisting of land which is improved in some way rather than left as unimproved grassland or rough ground. In total the project area covers 3,189.8 square kilometres and contains the full range of HLC Types.

Data was extracted from the Cornwall SMR. This consisted of a range of site types and find spots of prehistoric or Romano-British date and also those of early medieval date in order to compare the patterns of early medieval land use with those of the Romano-British period. This data was then correlated with the HLC polygons to quantify the number of sites captured in each HLC Type.

The methods used to create the models in the Lowland Cornwall project are based on a critical review of Dutch predictive modelling techniques published by Philip Verhagen (2007) of Leiden University. Dutch models contain three 'zones' of high, medium and low probability or potential. The formula for defining the three zones essentially measures the relationship between the proportion of sites in each HLC Type and the proportion of the study area taken up by each HLC Type.

The models were tested using data from the Cornwall Events Record by calculating, based on the model's results, how many Events we could expect to be captured in each HLC Type – if the actual number was significantly less than the expected number the model was rejected and *vice versa*.

As well as creating models using HLC Types as variables, models were made by correlating cropmark site distribution with bedrock geology, soils and the pattern of aerial reconnaissance, including a cropmark visibility model based on a combination of all these variables. The same method was used for building these models, and they were again tested using Events Record data.

The next stage in the project involved producing a deepened HLC. Resources did not allow for HLC deepening over the whole of Lowland Cornwall. Instead it was carried out in four discrete areas, named Penwith, Probus, Pelynt and Poundstock, covering 384 square kilometres in total. The characterisation was undertaken at a finer granularity than Cornwall's existing 1994 HLC, and for Enclosed Land the HLC Types were further divided into a number of Sub-Types.

As well as considering the present day landscape, characterisation was also carried out for previous time-slices – 1880, 1840, late medieval and, in Penwith, prehistoric. As well as historic maps, place-name evidence was used to provide context to the interpretation of the landscape.

Analysis of the sites located in each of the four study areas was then carried out, focused on morphological features (size, form and shape), position in the landscape and spatial distribution.

Following this, fine grained models were built for enclosures and barrows using HLC Types and HLC Sub-Types as variables. Models were made for each time-slice and, in the case of enclosures, for a combination of all the time-slices. Models were also built for all four study areas taken together. Testing of the fine grained models was carried out as before using Events Record data, but also by using partial data. This was done by creating a model for three of the study areas and then applying this to the fourth to gauge how well it fitted.

1.4 Main findings

1.4.1 The 1994 HLC models

- The models for enclosures and field systems support the suggestion that the medieval settlement heartland was also the prehistoric and Romano-British settlement heartland.
- Testing of the model for open settlements indicated that the enclosures model is a better indicator than the open settlements model of those areas where undiscovered unenclosed settlements are most likely to be located in the future.
- The barrows model suggested that plough-levelled barrows are likely to be located in a wide range of HLC Types.
- The finds spot model was rejected by testing, suggesting that the pattern of finds distribution presented by the SMR derives from a biased sample.

1.4.2 The geology, soils and visibility models

- The high probability zones of the models based on bedrock geology and soils for cropmarks lie mostly in central and west Cornwall whilst east Cornwall is ranked as medium or low probability.

- The cropmark visibility model shows only those areas where cropmarks are most likely to form and where they are most likely to have been seen; it therefore reflects 'absence of evidence' rather than 'evidence of absence'.
- Models correlating the distribution of enclosures with bedrock geology, with soils and with a combination of the two again suggest an east/west disparity, with much of the high probability zone lying in the west and central areas.

1.4.3 Lowland Cornwall deepened HLC

- HLC deepening showed that the extent of Rough Ground has diminished significantly over time in all four study areas.
- The HLC Type Medieval Enclosed Land has undergone significant change over time, with formerly larger fields being extensively sub-divided into smaller units by the time of the 1840 time-slice. By the 2011 time-slice most of the sub-dividing boundaries had been removed and many of the fields had been amalgamated into a number of larger fields. This is clear in all four study areas so can be taken to represent a countywide pattern.
- Some fragments of fields fossilising the prehistoric field pattern were identified in areas outside their previously recognised distribution.

1.4.4 Analysis of the archaeological resource

- Enclosures were the most numerous site type in the dataset, 90% of which were simple univallate types. Slightly more than half were curvilinear in form, the remainder being made up of roughly equal numbers of rectilinear enclosures and those with a mixture of straight and curving sides. There were a small number of more complex enclosures, with either more than one enclosing ditch or with an appended enclosure attached. The enclosures were predominantly small, only 10% enclosed more than 0.5ha.
- The great majority of the enclosures are located on hill slopes and most lie between the 70m and 145m contours. There was no obvious preference for any particular aspect in the landscape: the siting of enclosures appears to correspond to the general lie of the land.
- The enclosures are most often recorded with other features, including other enclosures, field boundaries or field systems, trackways, pits, and occasionally roundhouses and hillforts. In some locations there are dense concentrations of enclosures and associated features, demonstrating that in favourable locations there was considerable density and continuity of occupation in the prehistoric and Romano-British period.
- There are significantly fewer records for field systems than for enclosures within the four study areas. Two thirds are recorded as cropmarks and those with extant remains are largely confined to the Penwith study area.
- The fields are predominantly rectilinear but in the main the field systems are very fragmented, making it difficult to describe the individual field shapes any more precisely. It is likely that only the major field boundaries produce clear cropmarks and that sub-dividing boundaries do exist but are not visible.
- There are hints that some of the fields in the Probus study area are on a coaxial arrangement and that the small brick-shaped fields characteristic of the West Penwith uplands did extend into lowland areas of the Penwith study area.
- Almost half the barrows in the dataset had extant remains, with roughly equal numbers recorded as cropmarks and from documentary sources.
- Although the favoured location for the barrows was on hill slopes many are located on hill tops or ridges and the majority face all aspects.
- The barrows were predominantly identified as mounds, with only 18% recorded as ring ditches and only 10% as mounds and ditches. The predominant diameter size range was between 11m and 20m.
- There are notable clusters of barrows, including 19 groupings or 'cemeteries'. These are often located on high ground in prominent positions in the landscape. Elsewhere the barrows are loosely distributed throughout the study areas and at 116 locations barrows are recorded singly, apparently in isolation.

1.4.5 The Lowland Cornwall HLC models

- The Lowland Cornwall HLC Types produced models for enclosures that performed better in each of the study areas than the model based on the 1994 HLC.
- A common factor across all four study areas was that the highest-ranked Type was Medieval Enclosed Land.
- Better performing models were attained when HLC Sub-Types were used as variables and again the high probability zones were dominated by Medieval Enclosed Land Sub-Types.
- The best performing models were those in which combinations of Sub-Types across all time-slices were used as variables. These models had high and low probability zones and, within the high probability zone, a zone of very high probability. In all four study areas these very high probability zones captured large numbers of enclosures.
- However, when tested using partial data fewer enclosures than predicted were captured in the very high probability zones. This is most probably due to regional differences and differences in size between the four study areas.
- By contrast the overall high probability zones of these models, formed by Medieval and Prehistoric Enclosed Land, were validated by the tests, demonstrating that at a broad brush level the HLC Sub-Type models can be applied across the county.
- On the whole the Lowland Cornwall HLC models for barrows perform better than the 1994 model. There are differences, however, in the make-up of the high probability zones between the study areas.
- The model for all the barrows is problematic in that there is no clear pattern to the high probability zone.

2 Introduction

2.1 Project background

Lowland Cornwall consists of those areas of the county which are predominantly actively farmed, including land which is improved in some way rather than left as unimproved grassland or rough ground. These areas probably have the highest potential for buried archaeological sites in the county, but are poorly understood and increasingly subject to the impacts of major change in land use and development. To address this issue Cornwall Council has for some years been using Historic Landscape Characterisation (HLC) as a predictive tool for justifying planning conditions for development proposals, most notably in areas classed as Anciently Enclosed Land (AEL). The Lowland Cornwall project attempts to test this existing model and to develop a statistically-based method for predictive modelling of the lowland prehistoric and Romano-British landscape. Predictive models will better inform future management and land use decisions and increase confidence in responses to development proposals in areas where the Sites and Monuments Record (SMR) currently shows no below-ground features. The method may also have the potential for application in other parts of the country.

The project comprises an appraisal of currently available data from a range of sources in order to develop models of past land-use, settlement patterns and landscape development. Whilst the primary aim is to indicate areas of high archaeological potential, at the same time it addresses key research agendas and contributes towards developing our understanding of historic landscape character.

The idea for the project was developed from a series of discussions with the then County Archaeologist and other senior officers within Historic Environment, Cornwall Council (now Cornwall Archaeological Unit), and with the English Heritage South West regional and Characterisation teams. The project was commissioned by English Heritage (now Historic England) following the submission of a project design in early 2009 (Young 2009).

2.2 Aims and objectives

Aims

1. To demonstrate the potential and significance of below-ground archaeology in lowland Cornwall, in particular to develop a better understanding of the extent and character of the prehistoric and Romano-British landscape. This improved understanding will better inform development control and management and land use decisions in lowland Cornwall, the latter by highlighting those areas with high archaeological potential and thus higher priority in terms of most effective targeting of agri-environment schemes and other landscape-scale management initiatives. On a strategic level the better understanding and predictive modelling resulting from the project will provide a more meaningful context in which to specify the scope of future development-funded work and to assess the results of such work.
2. To define models for prehistoric settlement patterns and landscape development in lowland Cornwall and, by exploring the relationship between these patterns and the early medieval and medieval patterns of settlement and land use, gain a better understanding both of the development of Cornwall's early society and economy and of the character and patterning of the county's buried archaeological remains.
3. To test and review interpretations of the development and potential of Historic Landscape Character Types.

Objectives

1. To review currently available SMR, National Mapping Programme (NMP) and Events Record data. In particular to examine the range of settlement types, evidence for field systems and land use, and evidence for phasing and change.
2. To propose models for prehistoric settlement patterns and landscape development by linking the results of this review with HLC data to identify patterns in settlement distribution, in the spatial relationships between settlements and field systems, and in the relationships between areas of intense activity and areas which are apparently blank.
3. To review current interpretations of the development and potential of Historic Landscape Character Types by better defining the extent of Anciently Enclosed Land and Recently Enclosed Land HLC Types.

2.3 Dissemination

The project was carried out in four distinct stages and generated an enormous amount of data. This volume presents a synthesis of the methodology, results and conclusions from the project as a whole. Detailed accounts of the methodology and results of each stage of the project are contained in four previous volumes.

Volume 1. During stage one, data for selected site types was extracted from the Cornwall SMR and correlated with the existing HLC Types in order to identify recurring distribution patterns and to create high level predictive models. The methods used and the outcomes are presented in Volume 1.

Volume 2. During the second stage an assessment was made of the extent to which other factors such as soils and geology may influence known distribution patterns of below-ground archaeology. Further high level models were built based on correlations between site distribution and geology and soil types. The distribution of geology and soils was then joined with the pattern of aerial reconnaissance in Cornwall to produce a cropmark visibility map showing where below-ground archaeology is most likely to occur and where it is most likely to have been identified and recorded. Volume 2 presented the results of this research.

Volume 3. Stage three involved refining or deepening HLC in four selected study areas. The HLC deepening involved a more detailed analysis than that carried out for Cornwall's existing HLC. Specifically, some HLC Types were broken down into Sub-Types and characterisation was carried out for a number of time-slices. The results of the HLC deepening are presented in Volume 3.

Volume 4. Stage four involved building predictive models based on correlations between site distribution and the deepened HLC Types and Sub-Types within the four study areas to see whether more accurate and precise models could be achieved using the deepened HLC. A detailed analysis of the sites within each study area was also produced. Volume 4 presented the results of this work.

3 Location and setting

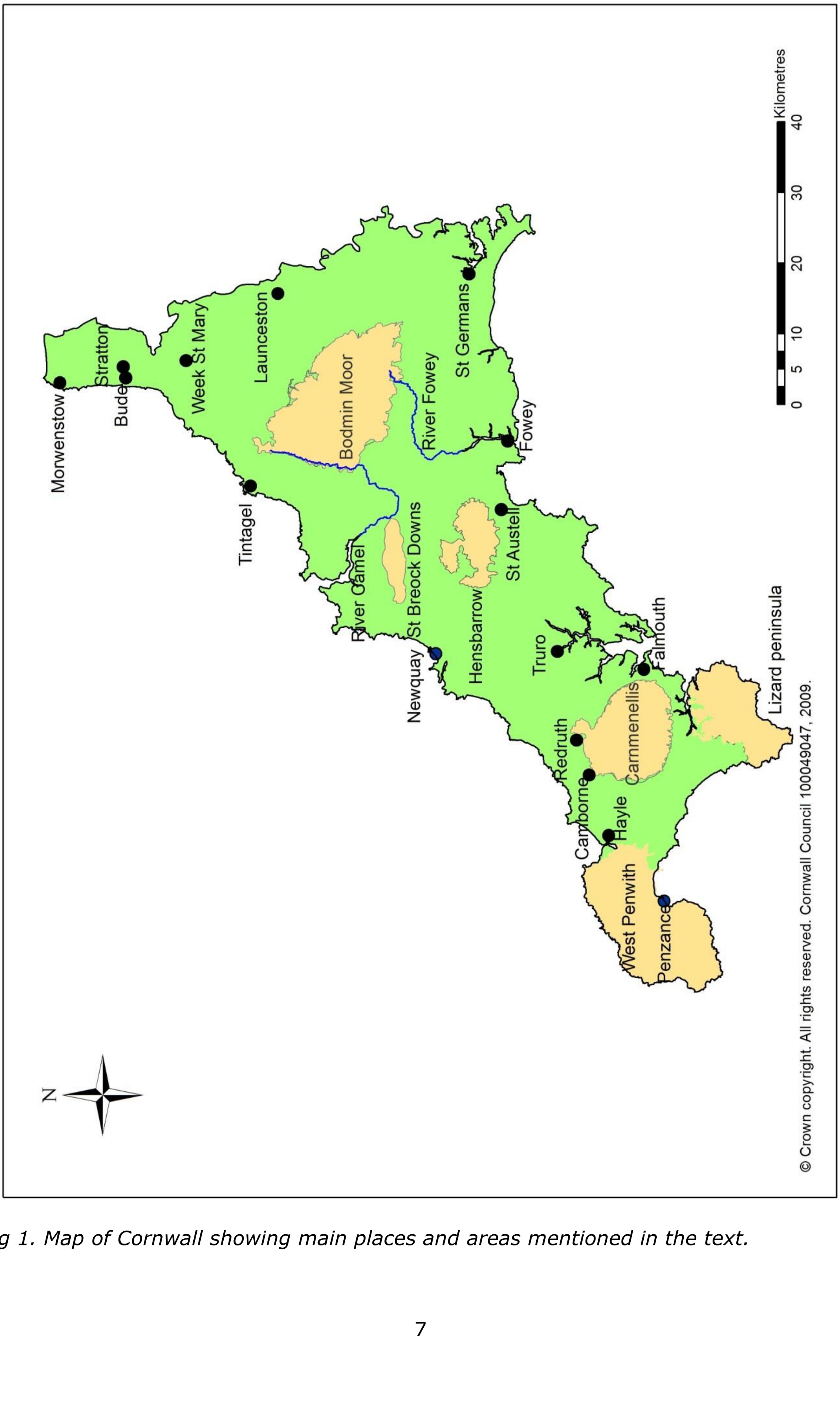

Fig 1. Map of Cornwall showing main places and areas mentioned in the text.

Cornwall is a long narrow peninsula measuring roughly 110km east to west (Fig 1). The county boundary with Devon in the east runs for approximately 70km along the line of the river Tamar. Cornwall's land mass totals approximately 3,800 square kilometres and the county's most obvious feature is its extensive coastline, which measures approximately 450km in length. The Atlantic coasts of north Cornwall, Land's End and the west side of the Lizard Peninsula are characterised by dramatic cliffs, whereas the Channel coasts of the south and southeast are more gentle in comparison. Along parts of the coast (particularly the south coast) river estuaries are characterised by finger-like inlets, and in some places the meandering tributaries have become silted up as a result of the deposition of alluvium and of waste washed down from mine workings further upstream.

The landscape is predominantly rural in character, and supports a mixed farming regime. Agriculture takes up 86% of the land and the farming landscape is characterised by a patchwork of mainly small fields, many resulting from the enclosure of open field systems in the late medieval and early post medieval periods. There are areas of unenclosed moorland: the most extensive occur on the Bodmin Moor uplands, but there are smaller areas on the Lizard Peninsula, in West Penwith and elsewhere. Areas of woodland are largely confined to the river valleys, but there are some forestry plantations in the north and northeast.

The population of 500,000 is housed largely in a dispersed network of farms, hamlets, villages and small towns. Truro is the only city and is the administrative centre of the county. The conurbation of Redruth and Camborne forms the largest settlement with a population of roughly 47,000 (figures provided by the Cornwall Council's Spatial Planning Department).

After farming, the most important industry in terms of land use area is tourism. This makes some claims on land, particularly in coastal areas, for amenity purposes (caravan parks, holiday complexes and such like), and has led to the post-war expansion of resort towns such as Newquay. China clay extraction is the only major active manufacturing industry, and is concentrated in the Hensbarrow area to the north of St Austell.

3.1 Geology

Cornwall is dominated by a spine of granite bosses, the four principal ones being Bodmin Moor, Hensbarrow, Carnmenellis and West Penwith. Lesser granite intrusions occur at Tregonning Hill, Carn Brea and Carn Marth in the west, and Kit Hill and Hingston Down in the east. Associated with the granite bosses are extensive areas of metamorphic aureole – surrounding rocks which have been altered by the heat of the intruding granite. Mineralization occurred during the cooling of the granite and metamorphic aureole, resulting in the intrusion of tin and copper in lodes (seams) running broadly east–west, and lead, zinc and iron in lodes running north–south. At a later stage some granites were altered, the most widespread result being the formation of Kaolinite (china clay) which is found most extensively on the Hensbarrow granite.

Away from the granite areas the surface geology of Cornwall comprises three main elements. The oldest rocks in the county, likely to be Pre-Cambrian in origin, are found on the Lizard peninsula. Most of these rocks have undergone subsequent metamorphosis and the Lizard Complex is a nationally important mass of intrusions, most notably of serpentine, gneiss, schists and some granite.

In the far northeast of the county are Carboniferous rocks forming the western edge of the Culm Measures which characterise extensive areas of west Devon. These deposits contain black shales, sandstones and thin limestones.

The underlying geology of most of Cornwall, however, consists of Devonian rocks. There are slight variations between the Lower, Middle and Upper Devonian beds, but generally the Killas, as they are known, are characterised by clays, shales, slates, siltstones and sandstones.

During the Pleistocene period Cornwall was in a periglacial zone subject to freeze/thaw processes. In the post-glacial period Cornwall has been subjected to sea level rise, resulting in a coast of submergence (for instance extreme low tides expose 'submerged forests' at several localities). Rias, or drowned rivers, are another feature of the increasingly submerged post-glacial coastline (e.g., the rivers Fal, Fowey and Helford).

3.2 Soils

Much of Cornwall is covered by poor soils and most of the agricultural land is classed as Grade 3 (good to moderate quality), Grade 4 (poor quality) or Grade 5 (very poor quality) in the Agricultural Land Classification of England and Wales (1972). Grade 2 arable land (very good quality) is largely confined to southeast Cornwall, around the estuaries of the Camel, Fal and Helford, and the Hayle River valley in the west. The only soils classed as Grade 1 (excellent quality) occur in a small pocket along the Hayle River valley.

Cornwall is covered predominantly by brown earths associated with stagnogley soils, brown podzolic soils and rankers (National Soil Resources Institute 2004, Cranfield University). The Devonian Killas, covering most of the county, yields a clayey loam with characteristically impeded drainage in the east, less so to the west of Truro. Much of the Lizard peninsula is characterised by loamy soils with a wet, peaty surface over a thin iron pan. In the northeast the Culm Measures yield wet, clayey soils.

Raw peat soils occur at the highest points on the granite, most notably on Bodmin Moor and the Hensbarrow uplands. Raw sands occur locally at Hayle, Perranporth and Padstow and are the result of sand being blown inland to form extensive dunes known locally as Towans.

3.3 Current models for prehistoric landscape development

Extensive archaeological fieldwork has mapped large tracts of Cornwall's surviving upland historic landscapes, in particular on Bodmin Moor and a substantial part of West Penwith (Johnson and Rose 1994; Herring *et al* 2016). Large scale analytical surveys have demonstrated the extent of the surviving prehistoric and medieval landscapes in these areas and provided a good understanding of how these landscapes worked. And HLC has enabled us to place the uplands into their Cornish context through the identification of much of lowland Cornwall (60% of the county) as Anciently Enclosed Land (AEL).

As a result some models of prehistoric landscape development for Cornwall have been proposed, the most developed of which was set out as a narrative in a paper by Peter Herring (Herring 2008). From different and superimposed settlement and field patterns Herring identified a series of key reorganisations of the Cornish farming system undertaken on a wide scale in response to changing pressures on land and resources within both upland and lowland zones.

The earliest definable patterns, from the Middle Bronze Age, can be traced on Bodmin Moor. Towards the fringes of the Moor, unenclosed roundhouse settlements are set within curvilinear accreted field systems. Lanes lead through the fields to rough grazing land on the open Moor beyond, which was probably shared with neighbouring groups as a form of common. In the heart of the Moor are settlements consisting of roundhouses but with few or no associated field enclosures. These are best interpreted as the seasonal homes of people practicing a pastoral economy and it is possible that the permanent bases of these people were in lowland areas surrounding the Moor.

A major reorganisation later in the Bronze Age involved the laying out of coaxial field systems with roundhouses scattered within them. These have been recorded from coastal rough ground on the Lizard Peninsula and in West Penwith as well as on Bodmin Moor.

Reorganisation in the Iron Age saw the abandonment of coaxial fields and the development of dense grids of brick-shaped fields. There was an intensification of agriculture (evidenced by the formation of substantial lynchets) and an increase in settlement nucleation demonstrated in the later Iron Age and Romano-British period by enclosed settlements and courtyard houses. This model is clearest in West Penwith (and to a lesser extent in other parts of west Cornwall and the Lizard Peninsula) where the layout of the main prehistoric boundaries have been encapsulated in the present day field pattern.

A far-reaching but poorly understood reorganisation took place during the sixth or seventh centuries AD. Enclosed settlements were abandoned and replaced by open hamlets, many of which have Cornish names prefixed with *Tre* (meaning 'farmstead'). Many of these early medieval settlements are situated close to abandoned prehistoric or Romano-British enclosed settlements, and it is suggested that some may be overlying the site of former Romano-British settlements (Rose and Preston-Jones 1995, Johnson 1998). The early medieval settlements may have been accompanied by the first strip fields, some of which may date as far back as the seventh century AD (Herring 1999a and b).

These episodes of landscape reorganisation, derived from upland evidence, appear to have been on a wide scale so it is reasonable to suppose that similar models can be demonstrated in lowland Cornwall. However, such a proposition has yet to be systematically tested. The potentially early medieval strip fields from which present day field patterns are largely derived were laid out apparently with little or no regard to the pre-existing Romano-British field systems, and much of lowland Cornwall has been subjected to centuries of relatively intensive ploughing. For these reasons the prehistoric and Romano-British settlement and field patterns form a largely buried landscape. At present we do not know the full extent of this landscape or how its various elements relate to each other in the way that we do for the uplands. We have keyhole glimpses of areas of potential, but are lacking a demonstration of its hidden extent on a scale that could provide both patterning across the landscape and an adequately detailed picture of the resource.

4 Data sources

The project aimed to develop predictive models of past land-use, settlement patterns and landscape development in order to demonstrate areas of high archaeological potential. The method involved the analysis and comparison of a range of datasets. Cornwall's SMR provided core data for the project, whilst three other principal sources of currently available data were also used.

4.1 HLC data

Historic Landscape Characterisation (HLC) aims to identify, describe, interpret and map the main historic influences which have shaped and defined the present day landscape. HLC is a national programme funded by HE. It is a GIS-based technique using polygons which reflect common historic characteristics. Each polygon is assigned to one of a pre-defined set of broad high-level HLC classes, such as 'Ornamental' or 'Woodland'. In Cornwall's HLC these high-level definitions are termed HLC Zones (Fig 2). These are further characterised to produce a set of HLC Types, such as 'Deer park' or 'Ancient woodland', reflecting visible extant historic character.

A key factor in the model for the prehistoric landscape outlined above is access to areas of rough grazing beyond the settlement and farming heartland. In Cornwall's HLC the historic landscape character zones Upland Rough Ground and Coastal Rough Ground are interpreted as having been largely unenclosed and used as grazing land. Much of the HLC Zone Recently Enclosed Land (REL) is interpreted as former rough ground, the greater part of which was enclosed in the nineteenth century. Taken together Upland Rough Ground, Coastal Rough Ground and Recently Enclosed Land can reasonably be taken to represent the extent of open downland in the medieval period and earlier.

Conversely the HLC Zone Anciently Enclosed Land (AEL) is interpreted as the medieval farming and settlement heartland and, by inference, the prehistoric and Romano-British farming heartland. There is much circumstantial evidence to support the proposition that AEL corresponds to the later prehistoric and Romano-British extent of farmed land (e.g. Herring and Perry-Tapper 2002). Indeed Cornwall Council has for some years been using HLC as a predictive tool for justifying planning conditions to development proposals, most notably in AEL (e.g. Clark *et al* 2004, 36). Nonetheless there are exceptions and the model is yet to be systematically tested. A key aim of the Lowland Cornwall project was to rigorously test this generally accepted model of AEL and its inter-relationship with Rough Ground and REL by using GIS to examine correlations between SMR data and HLC.

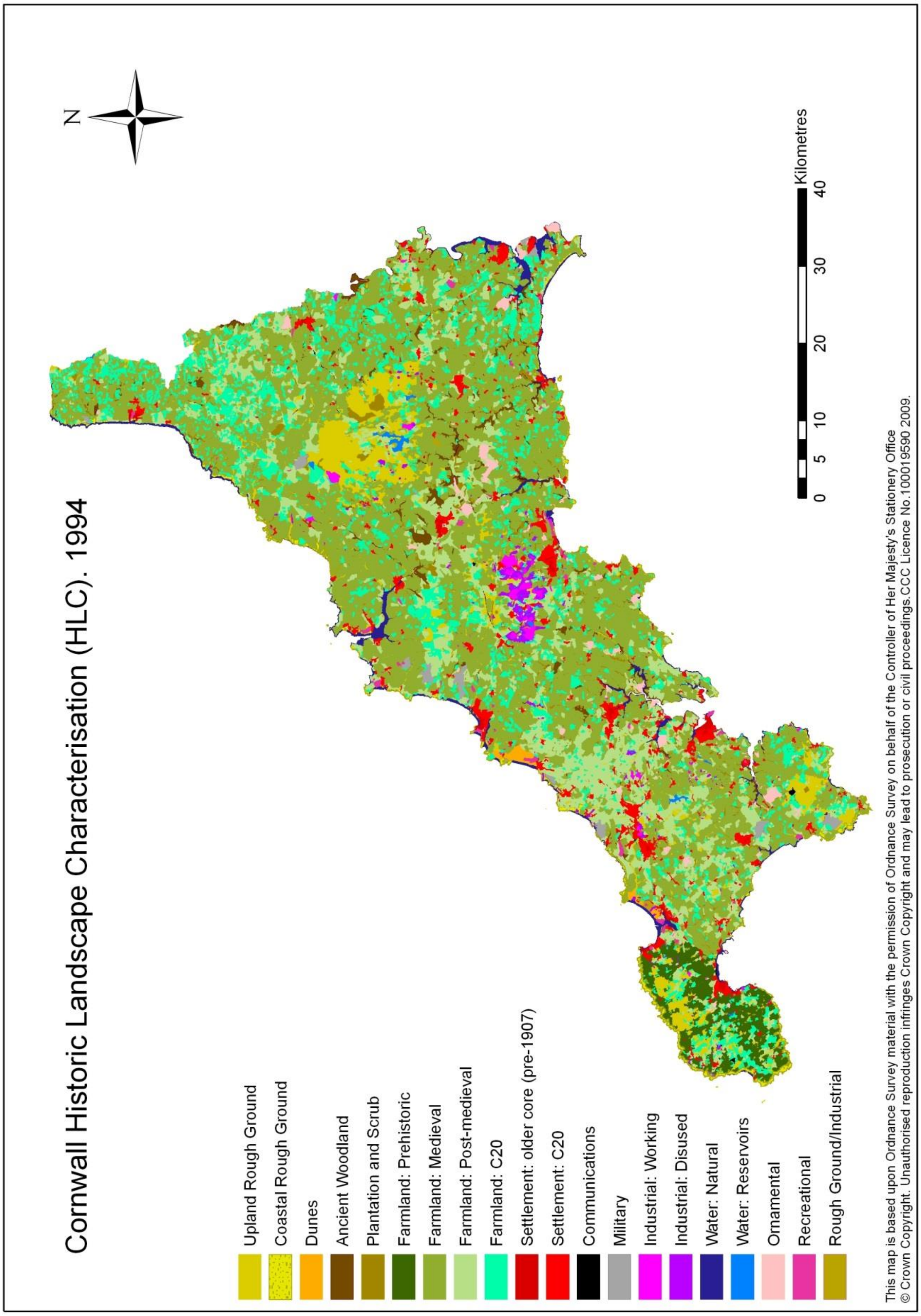

Fig 2. Historic Landscape Character Zones in Cornwall.

4.2 National Mapping Programme (NMP)

The National Mapping Programme is funded by HE and aims to map, describe, interpret and record all archaeological sites visible on aerial photographs in England to a consistent standard. Cornwall's project was initiated in 1994 and mapping for the entire county was completed in 2006 (Young 2007). More than 24,000 monument records in the Cornwall SMR were either created or enhanced by data from the project and 75% of the sites identified were new to the SMR.

In lowland Cornwall the most visible element of the prehistoric landscape is the distribution of more than 400 Iron Age/Romano-British enclosed settlements, traditionally known in Cornwall as rounds, which survive as upstanding monuments. The substantial banks and ditches of plough-levelled enclosures readily form cropmarks and a significant number of these have been identified from aerial photographs. During Cornwall's NMP more than 1,000 new enclosures were mapped and recorded, and in places NMP mapping revealed other elements of the buried prehistoric landscape. For example, in the area around the Camel Estuary, small enclosures (of uncertain function), field systems, trackways, and, occasionally, roundhouses were recorded (Young 2012). Nowhere, however, does NMP data provide a view of the prehistoric landscape as extensive or coherent as we have in West Penwith or on Bodmin Moor.

On a broad level, NMP mapping of enclosures indicates the currently definable Iron Age and Romano-British settlement pattern in lowland Cornwall. This settlement pattern is not uniform but is marked by apparent 'hotspots' and by significant gaps. Consideration should be given to the likelihood that some enclosures are overlain by later settlements (place-name evidence indicates that many of today's Cornish farms and hamlets were established in the early medieval period), and to the variability in levels of cropmark visibility resulting from underlying geology, soils, agricultural land quality, the extent of present arable and the uneven history of aerial reconnaissance. To date there has been no systematic assessment of the extent to which enclosure distribution is influenced by these factors.

Key elements of the project were an assessment of the degree to which these additional factors influence cropmark distribution and a comparison of the extent and character of the prehistoric landscape revealed by NMP mapping with the extent of the medieval farming heartland demonstrated by HLC.

4.3 Events Record data

The Cornwall and Isles of Scilly computerised Events Record has been compiled over the last three decades. It records all archaeological interventions for which a report has been produced and deposited with the HER team. These interventions include not only those carried out by CAU, but also those undertaken by other organisations. Information relating to the interventions is contained in a Microsoft Access database linked to a series of GIS polygons enabling direct access to the Event reports from the polygons displayed in GIS. In total 3,626 individual records were contained in the Events database when it was interrogated during the project. Reports are in PDF format and can be accessed by a link in the Events Record database.

This plainly constitutes a large amount of archaeological research. The greater proportion of this work had been carried out over the previous 15 years as a result of development-led interventions. Much of the data generated is contained in grey literature and there is a clear need to pull together this data and produce an appraisal of its significance. For this reason the project included an appraisal of Events Record data and a correlation of the evidence for below-ground prehistoric archaeology with the HLC.

Of particular importance are the geophysical surveys. Some are extensive and roughly 100 are associated with linear developments including a number of pipelines. The surveys have been carried out throughout all areas of the county, on a variety of geologies and using a range of techniques; they have frequently been followed up by evaluation and, sometimes, excavation. Important results of the surveys include the identification of enclosures not visible on aerial photography, associated field boundaries, roundhouses, and evidence for earlier activity in the surrounding landscape. Evidence for the pre-Iron Age landscape has been recorded in the form of Bronze Age roundhouses at a number of lowland locations.

4.4 Other data sources

National Record of the Historic Environment (NRHE) data

During Cornwall's NMP project a rapid assessment of NRHE data for a random selection of 1:10,000 OS map sheets was carried out. This suggested that no site records additional to those already contained in the SMR are held in the NRHE, other than a small number relating to the built environment. For this reason NRHE data was not consulted as part of the Lowland Cornwall project.

Place-name data

Using the Institute of Cornish Studies place-name index a list of named settlements, organised by parish, has been produced. This identifies the earliest recorded date for each settlement. This information has been plotted on 1:25,000 map overlays and was a key source for Cornwall's original 1994 Historic Landscape Characterisation and for the HLC revision element of the Lowland Cornwall project.

Portable Antiquities Scheme (PAS)

Data from the PAS in Cornwall was downloaded from the PAS website. This information was displayed as point data in the GIS to augment records for find spots contained in the SMR. PAS data was consulted during the course of the project but its usefulness was found to be limited.

Palaeoenvironmental data

Some information relating to palaeoenvironmental data is contained in the Events Record. This data was consulted during the project but was assessed as being of minor significance compared with the datasets listed above.

5 The Lowland Cornwall Project area

The geology of Cornwall is dominated by a spine of granite masses. Granite is resistant to weathering and these masses give rise to land of differing elevations but which are consistently above the level of the surrounding country. The granite masses of Bodmin Moor, Hensbarrow, Carnmenellis and West Penwith form the principal areas of high ground, in each case exceeding 150m in elevation. This granite landscape includes rounded hills, plateau tops, steep-sided valleys and rough vegetation and can reasonably be described as 'upland' in character. However, height above sea level in itself is not a definitive guide to identification of upland areas: there is a southerly tilt to Cornwall's land mass caused by uplift during the Mid-Tertiary (Stanier 1990, 20). As a result, both the area north of Bodmin Moor and that to the east of Bude contain similarly high ground, but these areas are characterised by extensive areas of farmland more typical of a 'lowland' zone.

The upland zone of Britain has in the past been described as containing human settlement which is essentially discontinuous, cultivated areas being separated by expanses of uncultivated hilly areas. In the lowland zone 'the plough lands stretch to the tops of the hills, settlement is essentially continuous, with villages and towns closely and evenly scattered, and the cultivated land of one parish merges with that of the next' (Stamp 1946). In the context of Cornwall the greater part of the lowland zone is characterised by 'farmland' – cultivated or improved land, including both ploughed land and grassland - interrupted by isolated patches of moorland, heaths and other unimproved lands. In essence lowland Cornwall can be defined as those areas of the county which are predominantly actively farmed, including land which is improved in some way rather than left as unimproved grassland or rough ground.

With this in mind it was clear that habitat data should form a key component in arriving at a definition of lowland Cornwall. The definition was reached by first identifying the upland zone of the county. Available sources of relevant data included the 1995 ERCCIS Habitat Land cover data, which indicated the extent of bracken, heath and unimproved grassland, and Agricultural Land Classification, showing the extent of Grade 5 and Non-agricultural land.

A further consideration was Cornwall's HLC. At the broadest level this distinguishes between 'enclosed land', equating to cultivated or improved land, and 'open land', equating to wastes, heathland and other unimproved land. The extent of open land was defined by mapping the HLC zones Upland Rough Ground, Upland Woods and Predominantly Industrial. The HLC zone Predominantly Industrial was included because it is confined for the most part to the Hensbarrow china clay area which was formerly made up predominantly of rough ground.

By juxtaposing the habitat, Agricultural Land Class and HLC mapping, an overall impression of the extent of the area with upland character was gained. To make a clearer distinction between those areas which are predominantly uplands and those which are predominantly lowland in character, polygons were drawn around the most extensive upland areas. These are Bodmin Moor, Hensbarrow, the Lizard Downs and parts of West Penwith. For this project, then, lowland Cornwall is defined as the non-shaded area in Fig 3. It is predominantly a farmed landscape with closely scattered villages, but does contain isolated tracts of unimproved wastes, woodland and rough ground. In total the Lowland Cornwall project area covers 3,189.8 sq km and the full range of HLC Types are found within it.

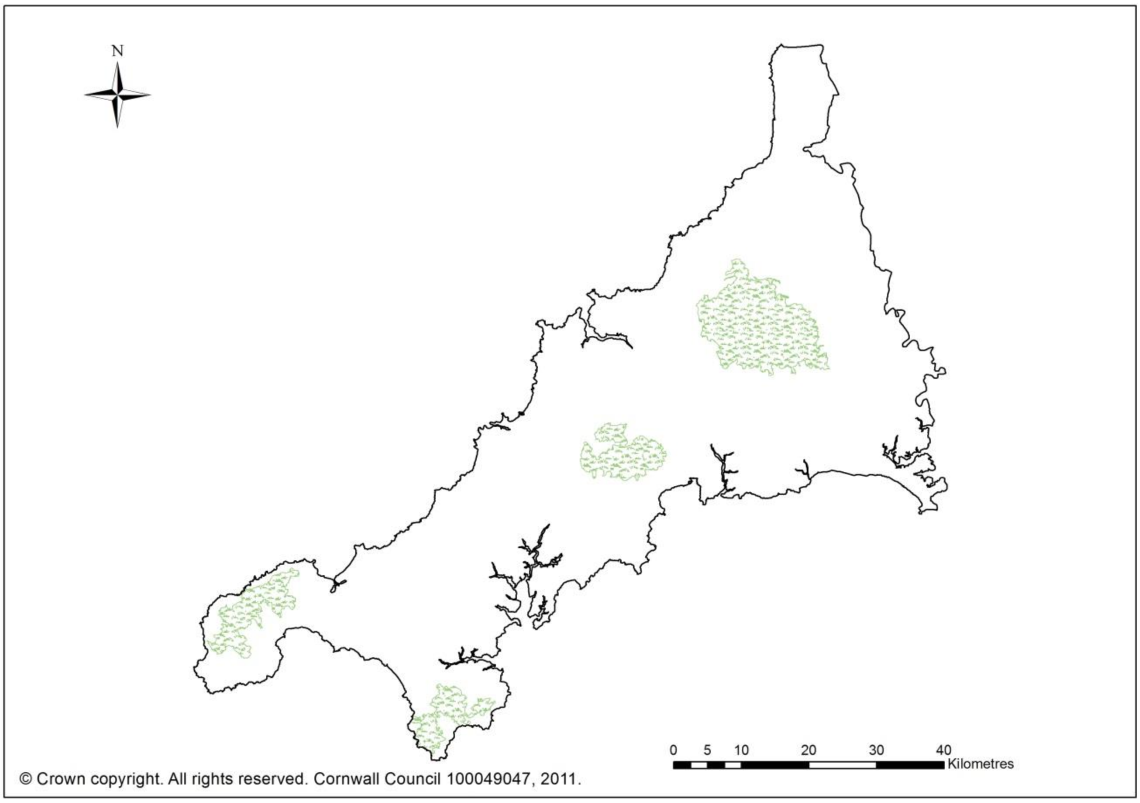

Fig 3. Map showing the Lowland Cornwall project area (non-shaded area).

6 Building the high level models

6.1 The Lowland Cornwall sites dataset

The first step in creating the predictive models was to extract the relevant sites from the SMR. The resulting data represents a snapshot of the archaeological record as it stood on the date it was extracted (April 2009). Any data added to the SMR after that date was not considered as part of the project. The selected site types were:

- Hillfort
- Hut circle
- Barrow
- Field system (where 'Display date' = Prehistoric)
- Field boundary (where 'Display date' = Prehistoric)
- Round
- Enclosure (where 'Display date' = Prehistoric)
- Find spot (where 'Display date' = Prehistoric)
- Early medieval settlement sites

The 'Display date' Prehistoric comprises a date range from Palaeolithic to the end of the Roman period. Early medieval sites were extracted so that the distribution of early medieval settlement could be compared with that of the Romano-British period.

Fields included in the dataset tables were:

- PRN (unique site ID)
- Site Type
- Period
- Display Date
- Form (*cropmark, earthwork, documentary, site of*)
- X and Y co-ordinates
- Morph Number (indicating whether the site was mapped during Cornwall's NMP and, if so, what confidence of interpretation level was allocated to it)
- Site Name

Data from the Portable Antiquities Scheme (PAS) was downloaded from the PAS website. Fields included in the PAS tables were:

- Find ID
- X and Y co-ordinates
- Primary Material
- Object type
- Object description
- Date from
- Date to
- Period from (prehistoric/RB periods only)

There were a number of issues associated with the process of extracting SMR data. Chief among these was the fact that some sites were multiple-indexed in the dataset. For instance, a site might be recorded in the SMR as either Iron Age or Romano-British in date and this site will appear twice in the dataset tables, once as an Iron Age site and secondly as a Romano-British one. For the data to be used for predictive modelling purposes it was essential that it was first filtered to produce a table containing a series of unique PRNs, each representing a single site, otherwise there would be the risk of the resulting models being heavily skewed by the multiple-indexed sites. The issue of multiple-indexing was particularly acute in the find spots dataset. Not only were there many alternative dating interpretations, but also more than one type of material found at the same site (e.g., flint, pottery, shell and wood) and more than one type of object falling into the same category of material (e.g., material = flint, object = fabricator, flake, blade). For many records all three of these factors applied and it was not unusual for any one find spot to appear in the dataset as 10 or more separate records.

A number of automatic data verification techniques were explored using ArcGIS and Access to remove all duplicate record numbers but none proved satisfactory. As a result, verification was carried out manually and a detailed account of how this was done was contained in Lowland Cornwall Volume 1, section 5.1.

In addition a number of site records were regarded as questionable and as far as possible these were removed from the dataset. There were three main types of dubious records.

Rounds

Records for rounds whose Form is *Documentary* were analysed. Most of these documentary references are derived from field-names. Field names containing the English element 'round', such as 'round field', 'round moor', 'round park', are now widely considered to be questionable as indicating evidence for rounds (see for example Quinnell 2004, 211). Therefore all records in this category were excluded. On the other hand relevant Cornish field-names (names with Cornish elements, such as 'Ker', 'Caer', etc. which usually refer to settlements of this form) were accepted as potential evidence and sites in this category were retained.

Hut circles

The listings contain a significant number of hut circles (roundhouses) identified in the field during the 1950s and early 1960s whose veracity has subsequently been questioned, mainly as a result of field visits by OS field workers or during later archaeological surveys. Therefore these records were excluded except in cases where subsequent observations have concurred with the original interpretations.

Records for hut circles whose Form is *Documentary* or *Site of* were analysed. Cornish field-name evidence, such as 'crilla' or 'crella' was accepted as potential evidence and these records were retained.

Barrows

A number of mounds visible on aerial photographs were mapped during Cornwall's NMP. The majority were multiple-indexed as Barrow, or Mound of unknown date. In some cases (those located in Cornwall's mining districts) they were multiple-indexed as Mound, Barrow, and Spoil Heap (Post Medieval). Given the level of uncertainty over interpretation of these features none were retained in the dataset.

Once the extracted data had been filtered the project sites dataset contained 8,969 records for individual sites and consisted of the site types shown in Table 1. These site types were taken forward into the next stage of the project, which involved correlating their distribution with HLC Types.

Site type	Number of sites	% of total sites
Barrow	2,120	23.64%
Early medieval site	2,116	23.59%
Find spot	1,641	18.30%
Round	1,332	14.85%
Enclosure	625	6.97%
Field system/field boundary	529	5.90%
Hut circle/roundhouse	288	3.21%
PAS find spot	231	2.58%
Hillfort	87	0.97%
Total	**8,969**	

Table 1. Summary of the Lowland Cornwall sites dataset.

6.2 Weaknesses of the available data

The reliability of statistical analysis of the type undertaken during the Lowland Cornwall project is dependent on the quality of data on which it is based. There are weaknesses in the sites dataset which need to be borne in mind when considering the results of the analysis.

The SMR was the primary source of information on archaeological sites and, in common with the SMRs of other local authorities and curatorial organisations, it has been compiled by a number of individuals over a relatively long time span. Inevitably this has led to inconsistencies in the way sites have been recorded from one decade to another and by individuals with differing interests and agendas. An obvious example of inconsistency is where a particular area has been subject to detailed survey and therefore has been recorded more comprehensively than areas where no survey has taken place. As an example, in one area an open settlement consisting of five roundhouses might have been input as a single record for 'settlement', but a similar site elsewhere might have been input as five separate records for 'roundhouse'. This type of inconsistency will have repercussions for any analysis of the data based on numbers of sites.

Another weakness of some SMR data is that it is based on interpretation rather than certainty. One example, mentioned above, is the discrediting by subsequent field survey of features in West Penwith previously interpreted as hut circles. There are two principal areas in which uncertainty arising from the interpretive nature of SMR data is a potential issue: enclosed settlements identified by place-name evidence, and cropmark features identified from aerial photographs.

There are many instances of visible remains of enclosures (and indeed hillforts) at, or very close to, farms or hamlets with indicative place-names (e.g., *Gear, Ker, Caer,* etc.). Whilst these are easily outnumbered by locations where there are no visible remains, it is possible that at such locations the Romano-British enclosure was abandoned in the early medieval period and a new settlement (with an indicative place-name) established nearby. Alternatively, the early medieval settlement was named in reference to the nearby abandoned enclosure. In either case it means that the place-name site is actually a duplicate record and should be excluded from the dataset.

Sites identified as cropmarks from aerial photographs are done so with varying degrees of confidence but were all treated as *bona fide* sites in the building of the high level models. Ideally a programme of ground-truthing of cropmark sites should be carried out before they can be included in a predictive modelling dataset but in Cornwall the resources which would be required for this would make such a task an unrealistic proposition. However, coincidental follow-up work has been carried out at a number of cropmark sites in Cornwall in recent years; at the majority the interpretations have been verified, but at a small number no evidence was found and a further appraisal of this type in the future would be a useful exercise. These issues surrounding interpretation were addressed in the preparation of predictive models for the four study areas by the use of a validity or confidence field in the dataset, but in building the high level models no site verification other than the rationalising of multiple-index issues was carried out.

There are also inherent weaknesses in Cornwall's HLC data. Cornwall was the first county to carry out HLC and the methodology at the time was in its infancy. The mapping was undertaken rapidly using paper maps at 1:50,000 scale reduced from the OS 1:25,000 map published at the time (the mapping was transferred at a later date in unrevised form into the GIS). More detailed examination of the HLC at specific locations as part of CAU desk based assessments and other projects over the last 23 years has shown that the HLC contains an unquantified number of errors arising from this rapid approach. These inaccuracies will doubtless have been carried forward into some of the predictive models presented here.

Whilst it is important to highlight these weaknesses the fact remains that the datasets constitute a large body of information of which the vast majority is accurate and credible. Although more comprehensive quality assurance of the various datasets and the implementation of a probabilistic sampling programme for model testing would be the ideal, the reality is that this ideal was beyond the resources available to the project.

6.3 Correlating site types with HLC

Cornwall's HLC was carried out as a two-stage characterisation, with HLC Types providing the most detailed representation of historic landscape character, and HLC Zones identifying broader patterns simplified and generalised from the Types (Herring 1998). In order to produce the high level models the sites dataset was correlated with HLC Types. The project area was covered by 20 Types which are briefly summarised here: more detailed descriptions are contained in Appendix 1.

- Ancient Woodland. Woodland recorded on nineteenth century OS maps.
- Coastal Rough Ground. Includes land in coastal areas that has never been enclosed, or improved land which has reverted either recently or in the past.
- Communications. Railway lines, civilian airfields, telecommunications and radio stations and most A roads.
- Dunes. Extensive areas of sand dunes, known in Cornwall as Towans.
- Farmland C20. Includes both twentieth century enclosure of rough ground and extensive internal boundary removal within earlier field systems which has altered their character.
- Farmland Medieval. Field boundaries in medieval-derived fields are usually sinuous and irregular, having been created by the enclosure of previously open field systems.
- Farmland Post Medieval. The fields are not strip-based and usually have perfectly straight boundaries.
- Farmland Prehistoric. Irregular field systems derived from patterns of small block-shaped fields associated with later prehistoric settlements.
- Industrial: Disused and Industrial: Working. These include extractive industries, processing plants, sewage plants, landfill sites and industrial estates.
- Military. Mainly Second World War airfields.
- Ornamental. The landscaped grounds of country houses.
- Plantation and Scrub. Woodland not classed as Ancient woodland.
- Recreational. Golf courses, camp sites and theme parks.
- Rough Ground/Industrial. Areas of rough ground containing the remains of industrial complexes where both are equally dominant.
- Settlement C20. The modern expansion of towns, villages and large hamlets.

- Settlement older core (pre-1907). The historic core of towns, villages and large hamlets.
- Upland Rough Ground. Includes land in upland areas that has never been enclosed, or improved land which has reverted either recently or in the past.
- Water: Natural. Natural bodies of water.
- Water: Reservoirs. Artificially created bodies of water.

The percentage of prehistoric, Romano-British and early medieval site records found in each HLC Type is shown in Chart 1 and a breakdown of site types in each Type in Charts 2 and 2a.

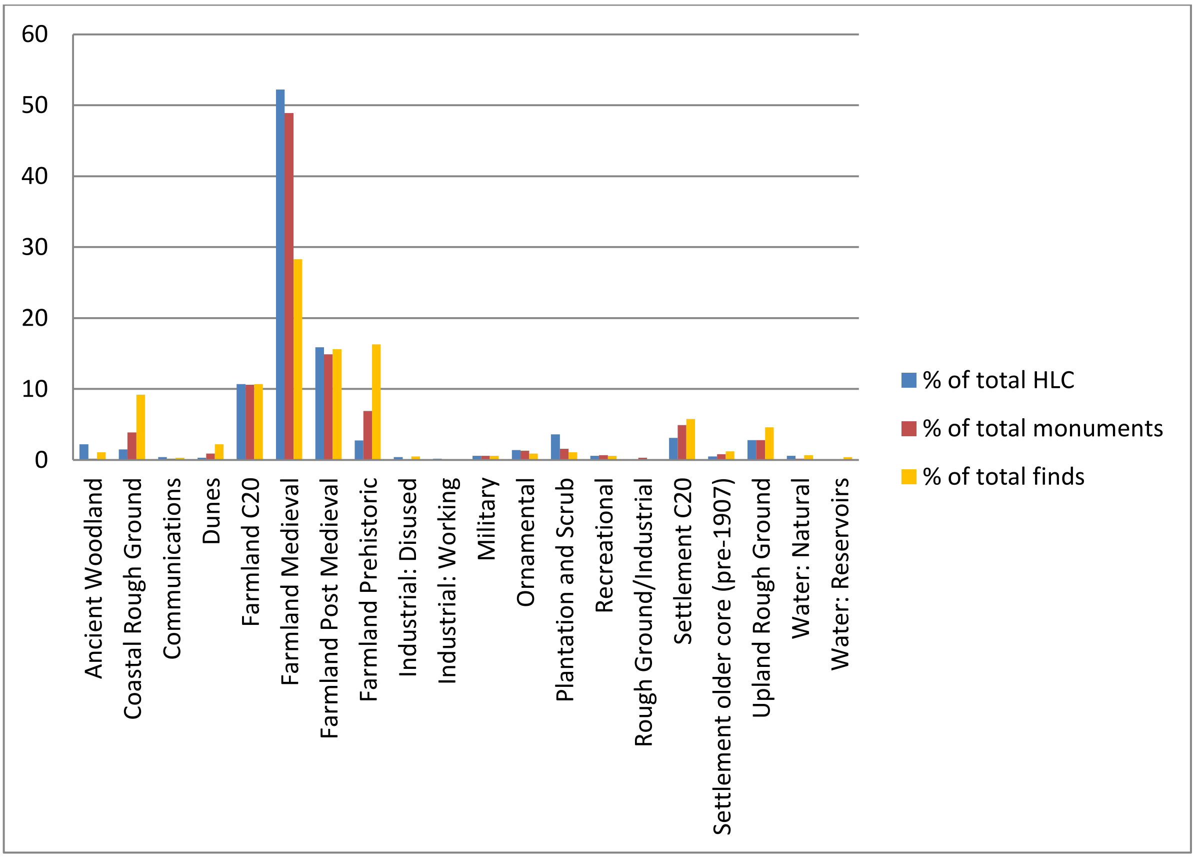

Chart 1. Chart showing HLC Types, the percentage of prehistoric, Romano-British and early medieval monuments and find spots recorded from each, and the percentage of the project area taken up by each HLC Type.

It is clear from Chart 1 that the HLC Types for farmland capture the great majority of the monuments (81%) and also the majority of find spots (71%). An apparent anomaly is the location of a small number of monuments and find spots in the HLC Type Water: Natural. Most of these are recorded from cliff top locations and some have been lost to coastal erosion. In other cases the distinction between high water and the edge of the land has been inaccurately defined in HLC. In some cases the sites may have been recorded in the SMR with slightly inaccurate grid references.

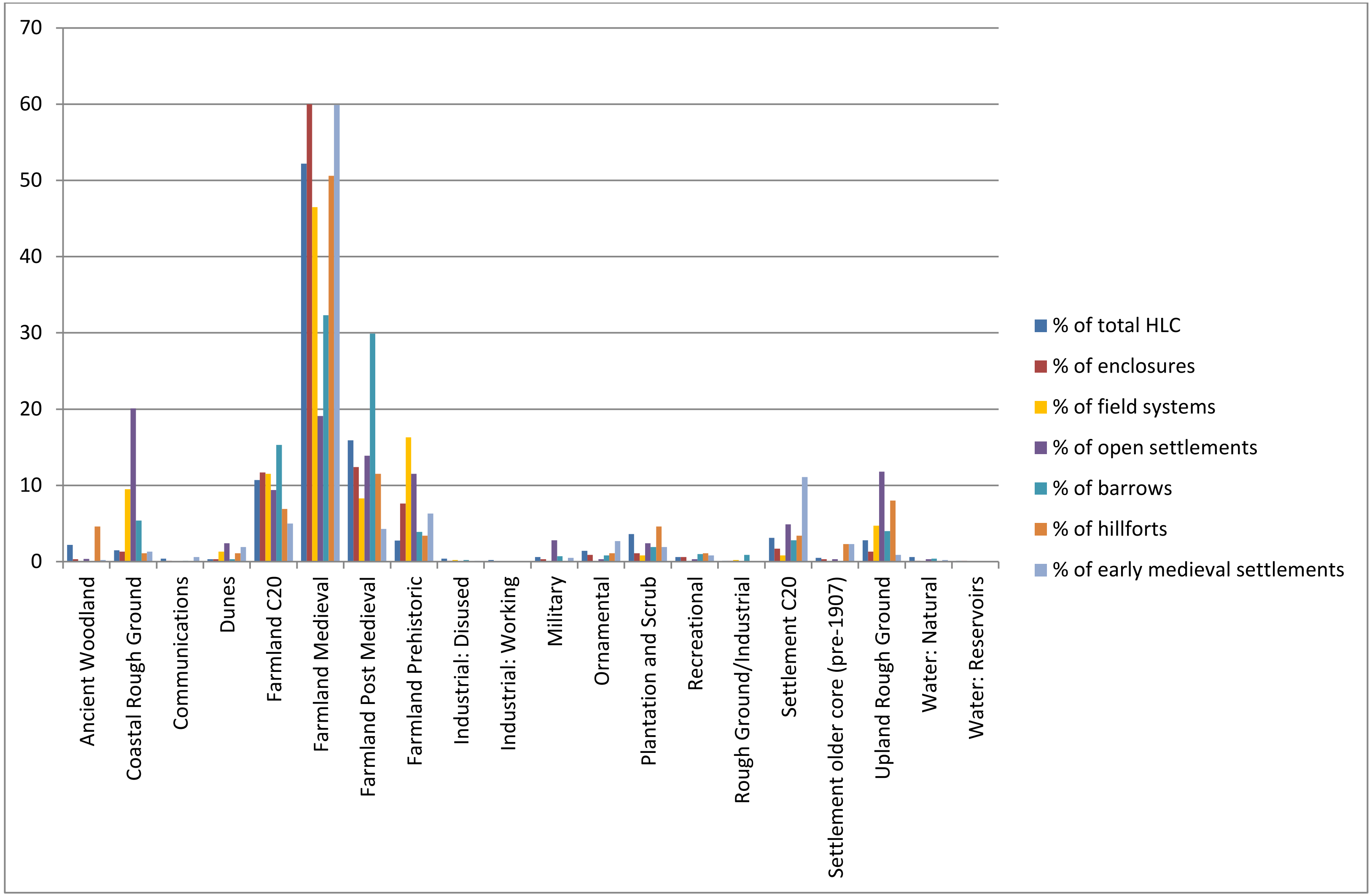

Chart 2. Percentage of monument types within each HLC Type.

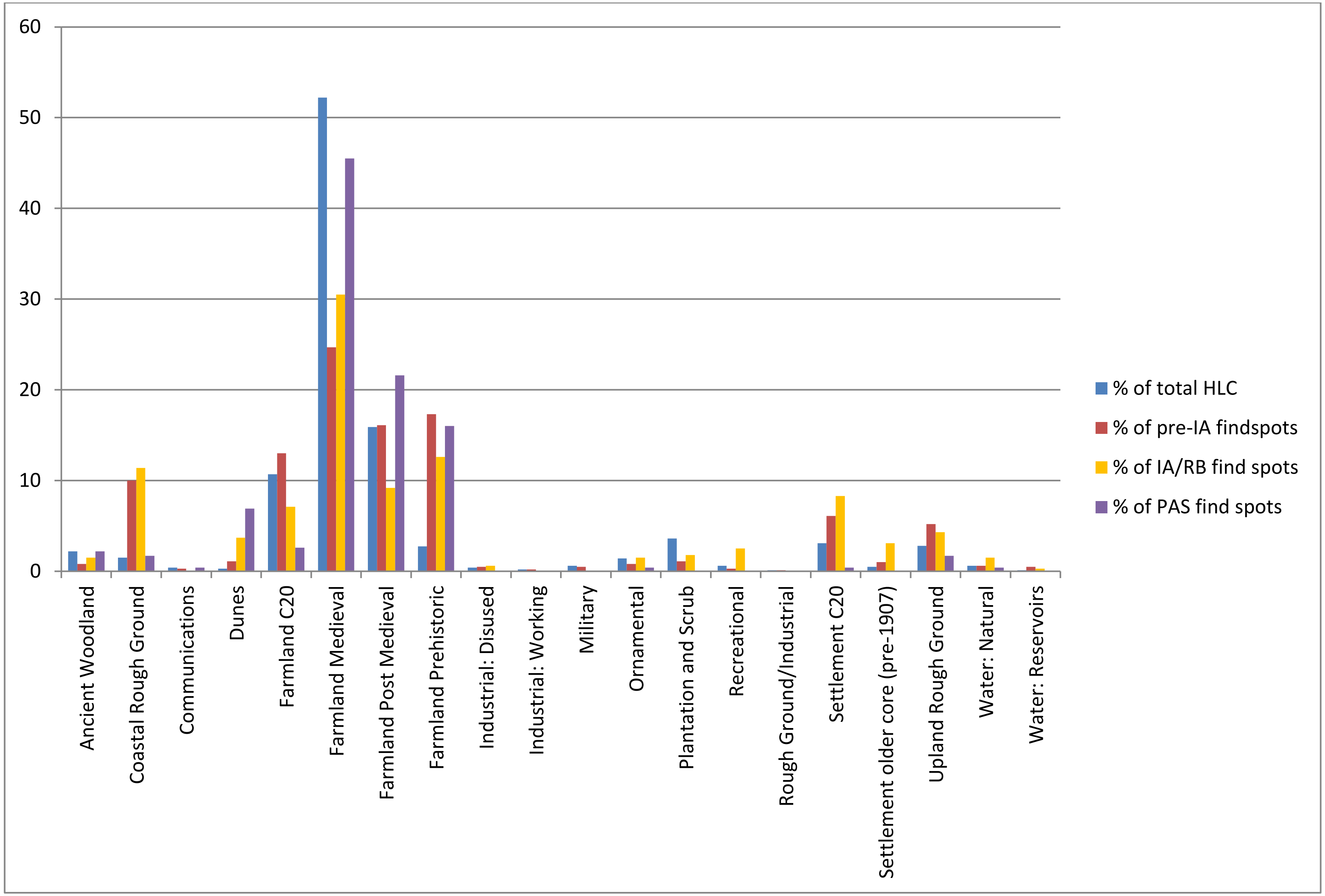

Chart 2a. Percentage of find spots within each HLC Type.

As Charts 2 and 2a show, the HLC Type Farmland Medieval captures the highest number of sites for all site types except open settlements. The number of rounds and enclosures situated in Farmland Medieval is particularly high, being the same proportion – 60% - as that of early medieval monuments. In fact when the HLC Zones are considered, Anciently Enclosed Land (AEL: Farmland Medieval and Farmland Prehistoric) captures 70% of the enclosures, 66% of the early medieval monuments and 62% of the field systems. By contrast only 24% of enclosures are located in Recently Enclosed Land (REL: Farmland Post Medieval and Farmland C20) and only 2.6% in rough ground. This pattern was entirely expected, as is the fact that more barrows (45%) are located in REL than AEL (36%).

Generally, rough ground Types capture fewer sites than AEL or REL. The exception to this are roundhouses (open settlement), 32% of which are located in rough ground as opposed to 30% in AEL and 23% in REL. This can, however, be partly explained by the fact that plough-levelled roundhouses are difficult to identify without geophysics or excavation. The find spots are rather more evenly distributed: for instance 42% of pre-Iron Age find spots are situated in AEL, 29% in REL and 15% in rough ground. However, the distribution of PAS finds differs from this, with 61% captured in AEL and only 3% in rough ground. This is probably because most PAS finds are from detectorists, who tend to work in ploughed fields rather than in rough ground.

6.4 Significance testing

6.4.1 The Chi-Squared test

The first step in creating viable models was to establish that these distributions were statistically significant; that is that they are not merely representing by-chance patterns. For instance, the fact that there are more enclosures in Farmland Medieval than any other HLC Type might simply be explained by the fact that Farmland Medieval is the most extensive HLC Type in the project area.

In order to establish statistical significance the Chi-Squared test was used. Chi-Squared is a standard statistical procedure (Lowry 2009), which measures the degree to which the actual (or observed) distribution pattern differs from the expected pattern.

In calculating the expected pattern it is assumed that the proportion of the total number of sites in any given HLC Type is equal to the proportion of the project area taken up by that HLC Type. This assumption is known as the 'null hypothesis'. If, when the test is run, there is a discrepancy between the expected number of sites and the actual number of sites observed, the null hypothesis is rejected.

In the Chi-Squared tests the null hypothesis was rejected on all the site types except hillforts (the full results of the tests were presented in Lowland Cornwall Volume 1, section 6 and Appendix 1). As a result of the tests it was concluded that there was a statistically significant correlation between site distribution and HLC Types and predictive models were built for all site types except hillforts.

6.5 Predictive modelling: theory and practice

The use of predictive models as an archaeological technique is particularly widespread in the United States and in the Netherlands. American predictive models are generally made using 'quadrats' (parcels of land) which produce either a site or non-site observation. By contrast Dutch models predict the relative density of sites in zones of 'high', 'medium' or 'low' probability, based on point observations of sites.

The Dutch three-zone models are the most appropriate for lowland Cornwall and the methods used during the project are based on a critical review of Dutch predictive modelling techniques published by Philip Verhagen (2007) of Leiden University.

The models aim to predict likely areas of prehistoric and Romano-British activity by correlating the distribution of known sites with perceived post-depositional land use patterns. There is strong documentary evidence in lowland Cornwall for the distribution of early medieval settlements, and current theory suggests a theme of continuity and change: although settlement design underwent radical changes (with the enclosed settlements characteristic of the Romano-British period superseded by unenclosed nuclear hamlets), the zone of settlement appears to have been perpetuated through time (e.g. Johnson 1998). The underlying premise is that early medieval settlement was located in the same areas as Romano-British settlement and that this pattern was determined by both environmental and cultural considerations. In other words, early medieval farmers lived at similar locations to their Romano-British predecessors and farmed the same land for both environmental considerations (e.g. swathes of fertile soil) and cultural reasons (e.g. precursor settlements and rights of tenure).

By analysing the shape and form of the present day field pattern, HLC identifies those areas which were farmed during the medieval period; the zone of settlement in the medieval and early medieval periods can be identified through place-name evidence. Taken together, these two strands of evidence enable us to define the zone of settlement and farming in the early medieval and medieval periods (Farmland Medieval). One aim of the Lowland Cornwall project is to use a statistical approach to test the premise that this zone is where we are also most likely to find prehistoric and Romano-British farms and settlements.

6.5.1 Clarification of terms and formulae

The Chi-Squared test is useful for determining statistically significant patterns between site location and HLC Types. However, Chi-Squared does not in itself indicate the relative 'importance' of HLC Types for site location. To indicate importance a range of mathematical formulae can be used. A number of widely used formulae as well as terms specific to predictive modelling are outlined below. It should be emphasised that some of the terms have a specific meaning when applied to predictive modelling, which may be slightly different from their everyday meaning; this is particularly the case with 'importance', 'accuracy' and 'precision'.

Zones of interest. The first step in designing a predictive model is to sub-divide the study area into a number of zones of interest. In the case of the Lowland Cornwall project the zones of interest are the pre-defined HLC Types.

Importance. The next step is to indicate the relative importance of each zone of interest. 'Importance' here equates to site density – the higher the density of sites in a given HLC Type, the more 'important' that HLC Type is considered in modelling terms.

PS and PA. Many formulae are currently used for calculating importance. In essence, however, they all revolve around the relationship between the proportion of sites in each zone of interest (PS) and the proportion of the study area taken up by each zone of interest (PA).

Indicative Value. The ratio of proportion of sites (PS) to proportion of area (PA) is a straightforward way to measure importance. This formula – PS/PA – is known as the

Indicative Value. An even simpler measure of site density is S/A – a calculation of the number of sites per square kilometre.

Kj parameter. A more complex formula - the Kj parameter - is a measure developed in the Netherlands (Wansleeben and Verhart 1995). This is the formula used during the Lowland Cornwall project. The measure is defined as: $\sqrt{(PS \times (PS-PA)/PW)}$. PW is the proportion of the area that does not include sites. Because the models for Lowland Cornwall used point data for sites rather than area, this factor can be ignored (see Verhagen and Berger 2007).

Relative Gain. Much effort has been directed at the issue of how best to measure the performance of archaeological predictive models and these techniques invariably involve the calculation of 'gain measures'. The simplest is the calculation of 'Relative Gain'. Relative Gain = PS-PA, resulting in theoretical values ranging from 1 to -1 (Wansleeben and Verhart 1995).

Kvamme's Gain. The most widely used gain measure is Kvamme's Gain (Kvamme 1988). This formula is: Gain = 1-(PA/PS). An important point about Kvamme's gain is that because PA/PS can never = 0, Kvamme's Gain can never reach the maximum 1: there is therefore always a maximum gain dependent on the model itself.

Whereas Kj parameters are used to rank each zone of interest in order of importance (basically they are used to construct the model) Kvamme's Gain is used to assess the overall performance of the model.

Accuracy and Precision. Assessment of the performance of a model takes into consideration two factors, Accuracy and Precision. Accuracy is a measure of correct prediction – are most of the sites captured in the high probability zone? Precision is a measure of how far the model has limited the high probability zone to as small an area as possible. The difference between Accuracy and Precision is illustrated in Fig 4 below.

These two factors, Accuracy and Precision, together determine the performance of the model. With a three-zone model Accuracy and Precision can be determined as a measure of the performance of each zone.

It should be noted here that whilst a good model should be both accurate and precise, capturing the highest possible number of sites in the smallest possible zone of high probability, this balance was sometimes difficult to achieve in the Lowland Cornwall project. The strategy adopted was to favour accuracy over precision because when planning decisions are being made conditions are less likely to be attached to developments outside the high probability zone: the less accurate the model, the greater the risk to archaeology in the low probability zone. Therefore all the models produced during the project favour accuracy over precision, aiming to capture 70% or more of the sites in their high probability zone.

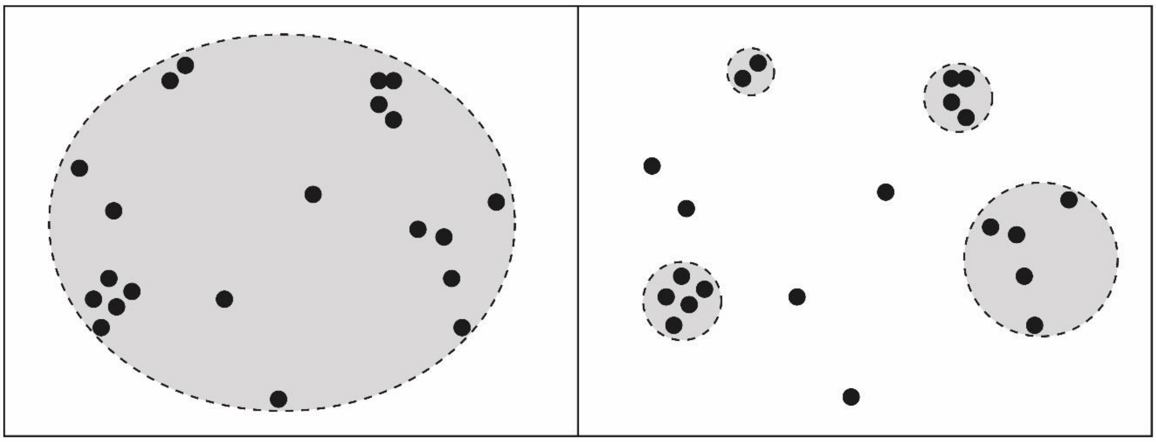

Fig 4. The difference between accuracy and precision. After Verhagen 2007, figure 7.1

The model to the left in Fig 4 is 100% accurate as it captures all the sites (points) in the high probability zone (shown in grey). The model to the right is less accurate but more precise, because the high probability zone is less extensive than that on the left.

6.5.2 Constructing the models

The application of Kj parameters is an iterative process. Kj is calculated for each HLC Type; the Type with the highest value is added to the model and excluded from the next iteration. Kj is then recalculated for the rest of the Types on the reduced total area. This process is repeated until all Types containing sites have been added to the cumulative model. The order in which a Type was added to the model is called its rank. When Types with a high potential for sites are added, the cumulative Kj value of the model increases: when medium or low potential Types are added, the cumulative Kj value decreases (Wansleeben and Verhart 1995).

The rank of an HLC Type indicates how good it is, relative to the other Types, at predicting the presence of sites. The top-ranked Types which increase the cumulative Kj are considered good predictors, those that have a minor negative effect or no effect are considered to have a medium quality prediction of sites and those that reduce the cumulative Kj are considered to have a strong negative predictive power (Verhagen 2007). In other words not only is the size of an HLC Type taken into account when measuring its relative importance, but defining the cut-off points between the three categories of high, medium and low probability is greatly facilitated by the use of the Kj calculation.

7 The high level models (1994 HLC)

7.1 Enclosures

The dataset contained 1,957 records for rounds and enclosures. Of these 1,047 are listed as cropmarks, 437 have above-ground extant remains, 431 are derived from documentary evidence, 38 are listed as known sites which have been destroyed, and four are recorded from geophysical surveys.

A significant majority (1,322) are classed in the SMR as rounds, only 635 as enclosures. However, no consistent set of criteria distinguishing a round from an enclosure appears to have been used when making this classification and for the remainder of this report these sites are referred to simply as enclosures. The great majority (1,436) are dated as Iron Age as opposed to Romano-British (only nine). However, this is because of the way the issue of multiple-indexing was resolved (Lowland Cornwall Volume 1, section 5.1.2); many of the Iron Age sites are likely to be listed in the SMR as IA/RB. In fact excavation evidence has indicated that the majority of those sites identified as 'rounds' are in fact likely to be Romano-British rather than Iron Age (Quinnell 2004, 212). Four hundred and eighty eight sites are interpreted as generic 'Prehistoric', 22 as possibly Bronze Age, one as Neolithic and one as 'Historic'. This latter case is an obvious inputting error (the site is interpreted as a round); the enclosures dated as Neolithic and Bronze Age may also be questionable.

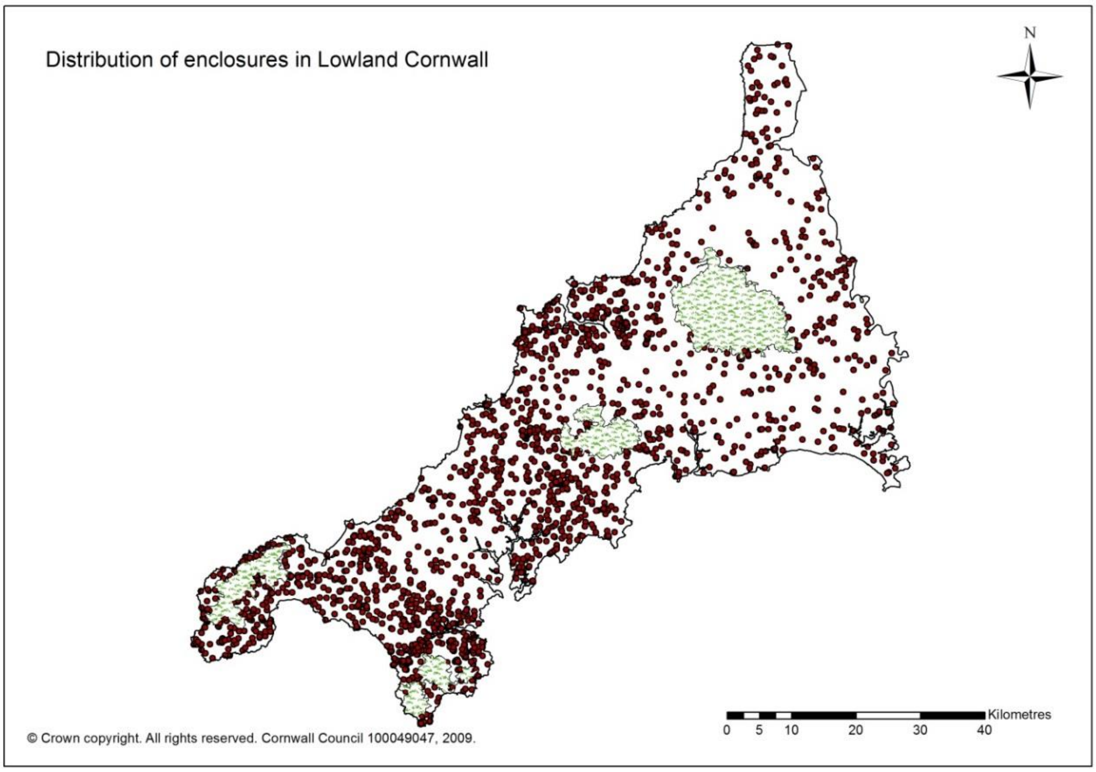

Fig 5. The distribution of prehistoric and Romano-British enclosures in lowland Cornwall.

The distribution of enclosures is not uniform across lowland Cornwall. Site densities are significantly higher in the western part of the county and there are notable concentrations in central and western areas (Fig 5). Whilst archaeological factors are probably involved in the uneven distribution, analysis of the dataset suggests that the clustered distribution is due in some measure to the nature of the evidence for the sites. This is clearly the case with enclosures listed as cropmarks which cluster in a number of hot spots: for instance the Camel Estuary and the northern part of the Lizard Peninsula (Fig 6). Enclosures identified from Cornish place-name evidence are largely absent from east Cornwall where English place-names predominate (Preston-Jones and Rose 1986, 141-143). By contrast, the distribution of extant enclosures (those with earthwork remains) is more even throughout the project area (Fig 7).

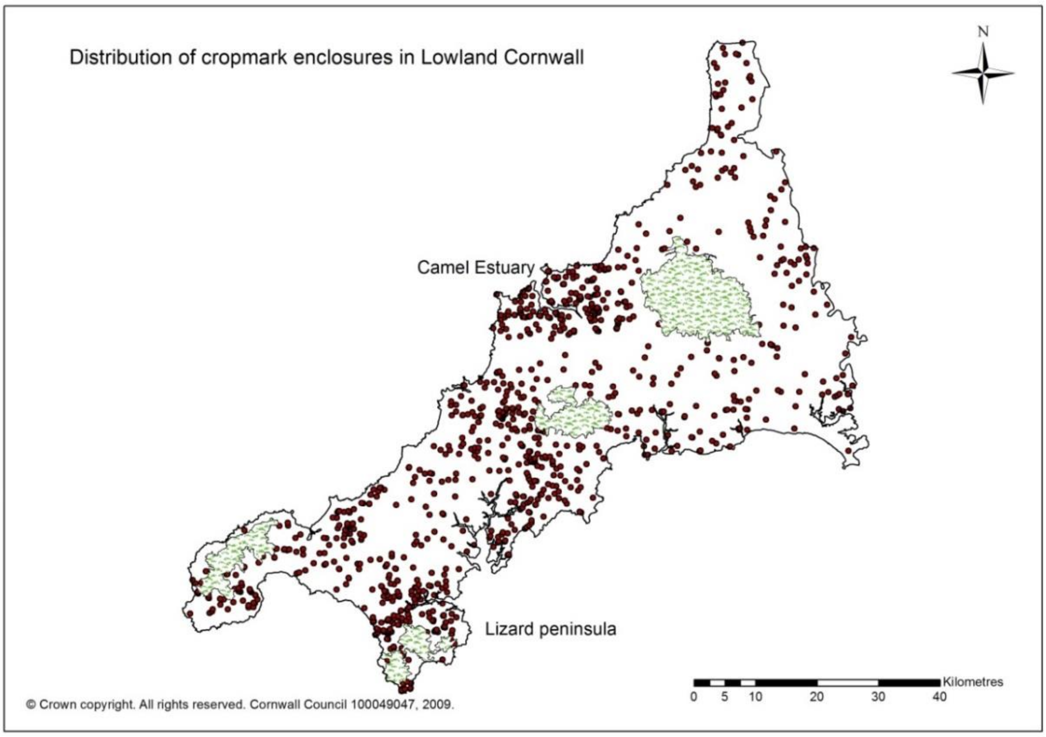

Fig 6. The distribution of cropmark prehistoric and Romano-British enclosures in lowland Cornwall.

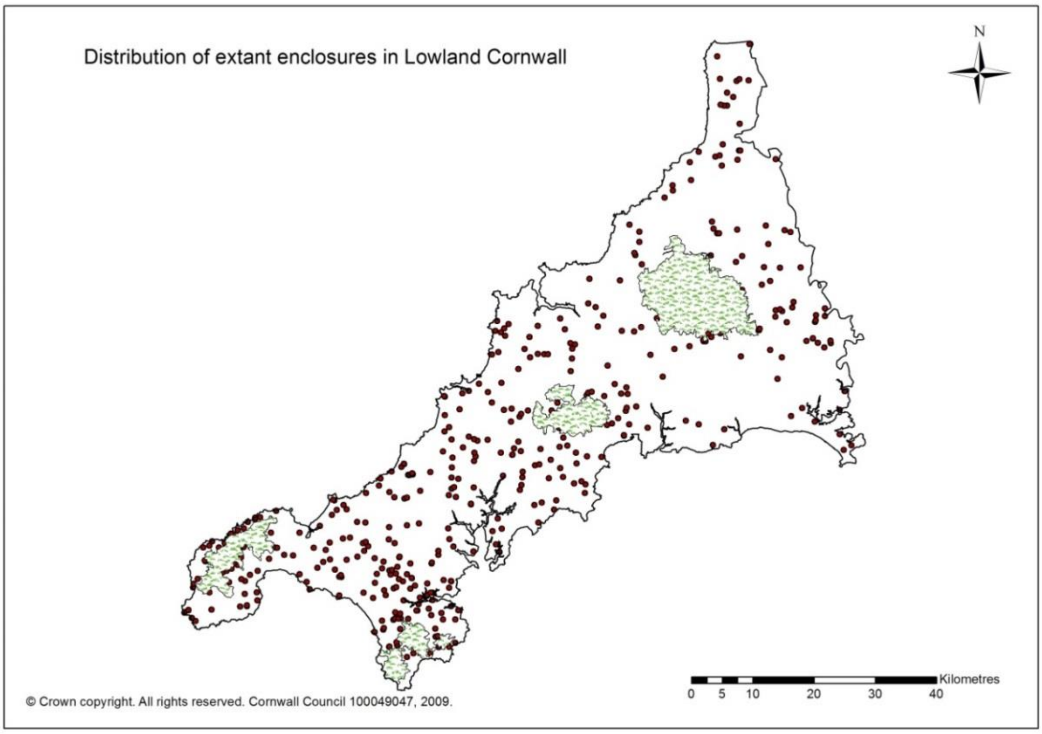

Fig 7. The distribution of extant prehistoric and Romano-British enclosures in lowland Cornwall.

The high level model based on the distribution of enclosures correlated with HLC Types is summarised in table 2 below.

	Enclosures. High probability zone				
Rank	**HLC Type**	**Sites**	**PA**	**PS**	**Kj**
1	Farmland Medieval	1,175	0.522	0.600	0.218
2	Farmland Prehistoric	148	0.028	0.076	0.293
3	Farmland C20	228	0.108	0.117	0.328
	Total	**1,551**	**0.658**	**0.793**	
	Enclosures. Medium probability zone				
	HLC Type	**Sites**	**PA**	**PS**	**Kj**
4	Farmland Post Medieval	243	0.160	0.124	0.303
5	Coastal Rough Ground	25	0.015	0.013	0.302
6	Dunes	5	0.003	0.003	0.248
7	Recreational	11	0.006	0.006	0.248
8	Rough Ground/Industrial	2	0.001	0.001	0.179
	Total	**286**	**0.185**	**0.147**	

Table 2. Predictive model for enclosures based on the correlation with HLC Types.

The Kj values continue to increase until the fourth-ranked HLC Type (Farmland Post Medieval) is added to the model, after which they fall from 0.328 to 0.303, thereby defining the cut-off point between high and medium probability zones. The medium probability zone is composed of the fourth to eighth-ranked Types. All other HLC Types make up the low probability zone. The performance of the model is shown below.

Probability zone	**PA**	**PS**	**Kvamme's gain**	**PS/PA**
High	0.66	0.79	0.172	1.21
Medium	0.19	0.15	-0.266	0.79
Low	0.16	0.06	-1.580	0.39

The high probability zone performs rather weakly, with a Kvamme's gain of less than 0.2. The low Kvamme's Gain indicates that the model lacks precision – because the high probability zone takes up as much as 66% of the project area (Fig 8). The strength of the model is that it is accurate – 79% of sites are captured in the high probability zone and only 6% in the low probability zone.

A more nuanced view of model performance can be achieved by looking at the relationship between all three zones rather than measuring the performance of only the high probability zone. In terms of the overall model, Kvamme's Gain for the low probability zone should be a negative figure, and that for the medium zone should fall somewhere between the low and high gain measures. Despite the low gain measure of the high probability zone, the model's overall performance is consistent. The ratio of Indicative Values for the high and medium probability zones is 1.53 and for the high and low probability zones is 3.1. This means that the likelihood of encountering a site in the high probability zone is 1.5 times higher than in the medium probability zone and more than three times higher than in the low probability zone. The chances of encountering a site in the medium probability zone are twice as high as in the low probability zone.

The model's lack of precision is clearly illustrated by the probability map derived from it (Fig 8). Large tracts of lowland Cornwall are classed as the high probability zone. The most extensive zone of medium and/or low probability covers parts of central west Cornwall roughly comprising the central mining districts. Other notable areas forming the medium or low probability zones are St Breock Downs in central north Cornwall, and a number of locations in the east and northeast of the county.

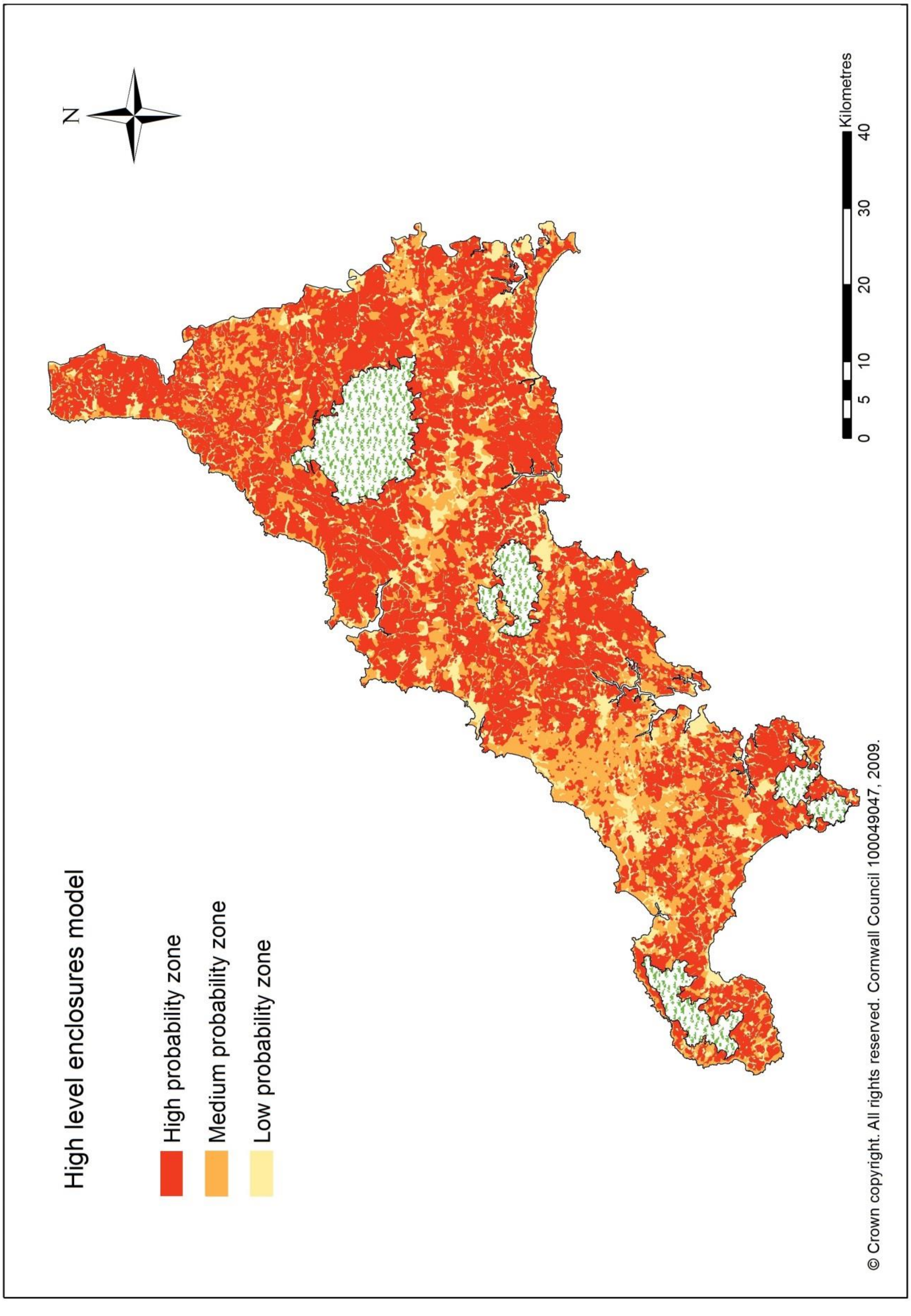

Fig 8. Probability map for the high level HLC model for enclosures.

Models were also made for only the cropmark enclosures and for only the extant enclosures. The high probability zone of the cropmark model was formed by Farmland Medieval and Farmland C20, with Farmland Prehistoric dropping into the medium probability zone. Presumably this reflects the fact that many of the fields in this HLC Type are typically small and are used as pasture, resulting in a lower number of cropmarks here relative to other enclosed land Types. The high probability zone of the extant enclosures model contained the same three highest-ranked Types as the all enclosures model but they were joined by Coastal and Upland Rough Ground.

The fact that there were more cropmark enclosures in the model's high probability zone than extant sites and those recorded from documentary sources combined suggested that the model might simply be showing those areas where cropmarks are most likely to be visible. However, it is also the case that three times more extant enclosures are found within the high probability zone of the model than in the two other zones combined, indicating that any bias towards cropmark-rich areas in the model is limited

Based on this model the assertion that the HLC Zone Anciently Enclosed Land (comprising the Types Farmland Prehistoric and Farmland Medieval) represents the zone of settlement in the later prehistoric and Romano-British period can be seen to be correct – these are the two highest ranked HLC Types in the model. Although the model is not very precise it does work effectively as a three-zone model, with Kvamme's Gains suggesting enclosures are three times more likely to be encountered in the high probability zone than in the low.

7.2 Field systems

The field systems dataset was created by extracting from the SMR all sites interpreted as field system or field boundary with a display date of Prehistoric, of which there are 529 in total. Of these one is dated as Neolithic, 15 are dated as Bronze Age, 104 as Iron Age or IA/RB, 18 as Romano-British and 391 as generic 'Prehistoric'.

The distribution of field systems is characterised by clusters, most notably in West Penwith, the Camel Estuary and around the Lizard peninsula. There are several large relatively blank areas (Fig 9).

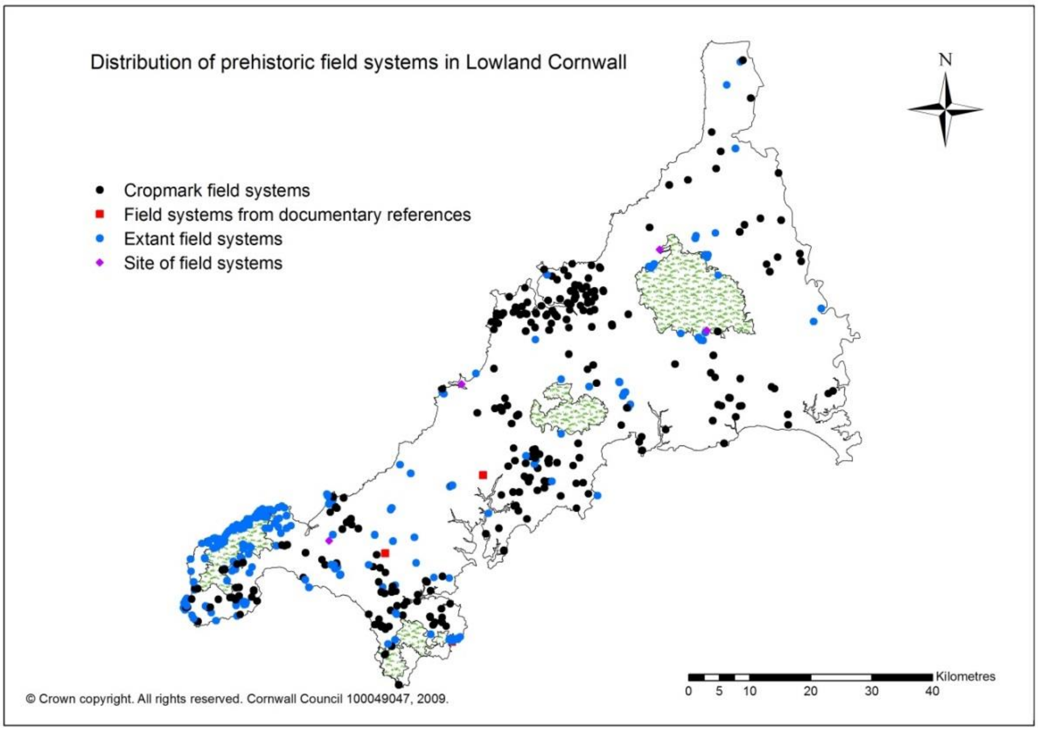

Fig 9 Map showing the distribution of prehistoric field systems in lowland Cornwall.

The dataset is made up almost exclusively of field systems whose form is either cropmark or extant: only five are recorded as 'site of' and three from documentary evidence. The ratio of cropmark sites to extant is close to 50:50.

There are two contrasting components to this distribution. Firstly fields recorded as cropmarks. These make up the clusters around the Camel and Helford Estuaries, and the sites recorded from east Cornwall (Fig 9). Secondly, those fields recorded as extant sites. These are concentrated to a large degree in West Penwith. Here many are located in Farmland Prehistoric (this HLC Type is confined to West Penwith) and in Coastal Rough Ground where the incidence of prehistoric fields extending beyond areas of farmland onto the cliff tops is well-documented (e.g. Herring 2008).

The make-up of the high probability zone of the field systems models is set out below.

Rank	Field systems: High probability zone				
	HLC Type	**Sites**	**PA**	**PS**	**Kj**
1	Farmland Prehistoric	86	0.028	0.163	0.148
2	Coastal Rough Ground	50	0.015	0.095	0.235
3	Farmland Medieval	246	0.522	0.465	0.338
4	Farmland C20	61	0.108	0.115	0.373
5	Upland Rough Ground	25	0.028	0.047	0.404
	Total	**468**	**0.701**	**0.885**	
	Field systems: Medium probability zone				
	HLC Type	**Sites**	**PA**	**PS**	**Kj**
6	Farmland Post Medieval	44	0.160	0.083	0.323
7	Dunes	7	0.003	0.013	0.341
8	Settlement C20	4	0.031	0.008	0.307
	Total	**55**	**0.194**	**0.104**	

Table 3. Predictive model for prehistoric field systems based on the correlation with HLC Types.

The make-up of the high probability zone is somewhat similar to that of the extant enclosures model, with Coastal and Upland Rough Ground accompanying Farmland Prehistoric, Medieval and C20, albeit ranked in a different order. Farmland Post Medieval is again ranked in the medium probability zone. The low probability zone is composed of all other HLC Types not listed in table 3. A probability map based on the model is shown in Fig 10.

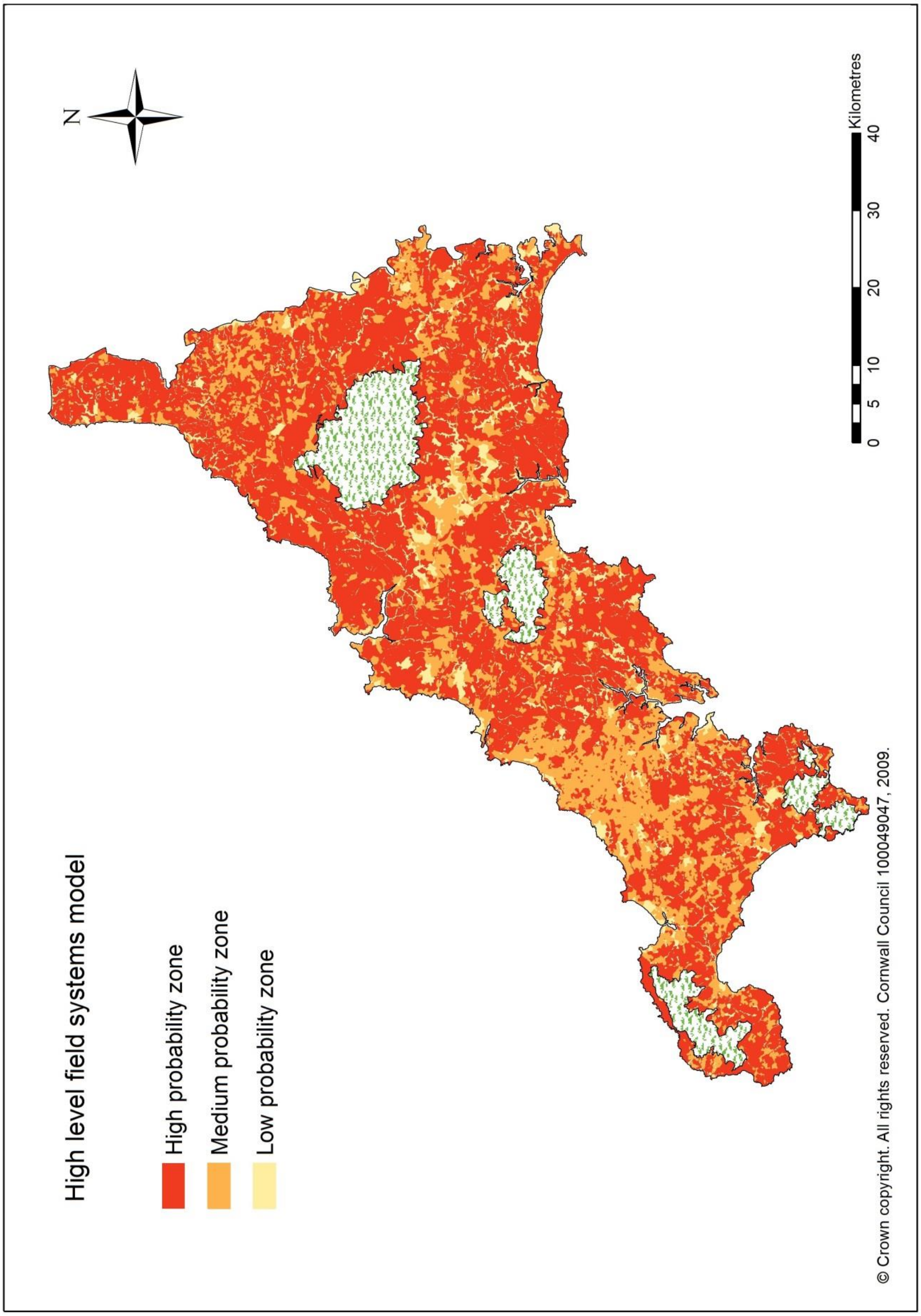

Fig 10. Probability map for the high level HLC model for field systems.

There are similarities between the performance of this model and that of the enclosures model. It is very accurate in that 88% of the sites are captured in the high probability zone but lacks precision because this zone covers 70% of the project area, thereby producing a low Kvamme's gain. The low and medium probability zones are defined precisely and accurately (12% of sites in 30% of the project area).

Probability zone	PA	PS	Kvamme's gain	PS/PA
High	0.70	0.88	0.209	1.26
Medium	0.19	0.11	-0.861	0.53
Low	0.11	0.01	-8.384	0.09

There are also similarities between the probability maps of the two models. For instance, the central mining districts around and to the south of Camborne and Redruth form much of the medium probability zone in each mode; in each model the area to the southwest of Bodmin Moor contains extensive tracts of medium and low probability zones.

However, in the field systems model the patterns of cropmark and extant site distribution within the various HLC Types are diametrically opposed. For instance, 96% of the field systems in Coastal Rough Ground and 77% of those in Farmland Prehistoric have extant remains, whereas the figure for extant sites in Farmland Medieval is only 19%. By contrast, 80% of field systems in Farmland Medieval are listed as cropmarks, whilst the corresponding figures for Coastal Rough Ground and Farmland Prehistoric are only 2% and 22% respectively. Thus in the model the disparity between the distribution of cropmark and extant field systems is effectively neutralised and this may have implications for its reliability. For this reason two additional models were developed; for cropmark and for extant field systems.

The high and medium probability zones for cropmark field systems contain the following HLC Types (all other HLC Types make up the low probability zone).

Rank	Cropmark field systems: High probability zone				
	HLC Type	**Sites**	**PA**	**PS**	**Kj**
1	Farmland Medieval	198	0.522	0.692	0.344
2	Farmland C20	38	0.108	0.133	0.402
3	Farmland Prehistoric	19	0.028	0.066	0.458
	Total	**255**	**0.658**	**0.891**	
	Cropmark field systems: Medium probability zone				
	HLC Type	**Sites**	**PA**	**PS**	**Kj**
4	Farmland Post Medieval	29	0.160	0.101	0.419
	Total	**29**	**0.160**	**0.101**	

Table 4. Predictive model for prehistoric field systems based on the correlation of cropmark field systems with HLC Types.

Probability zone	PA	PS	Kvamme's gain	PS/PA
High	0.66	0.89	0.267	1.35
Medium	0.16	0.10	-0.577	0.63
Low	0.18	0.01	-25.235	0.05

Whilst the model is very accurate with 89% of the sites captured in the high probability zone and only 1% in the low probability zone, the high probability zone lacks precision and therefore results in only a modest Kvamme's gain, albeit higher than that achieved by the model based on all field systems.

The results are very different in the model for extant sites which is summarised in Table 5 below (all other HLC Types make up the low probability zone).

Rank	Extant field systems: High probability zone				
	HLC Type	**Sites**	**PA**	**PS**	**Kj**
1	Farmland Prehistoric	67	0.028	0.285	0.271
2	Coastal Rough Ground	48	0.015	0.204	0.468
3	Upland Rough Ground	22	0.028	0.094	0.546
4	Farmland C20	21	0.108	0.089	0.576
5	Dunes	7	0.003	0.030	0.605
	Total	**165**	**0.182**	**0.702**	
	Extant field systems: Medium probability zone				
	HLC Type	**Sites**	**PA**	**PS**	**Kj**
6	Farmland Medieval	47	0.522	0.200	0.424
	Total	**47**	**0.522**	**0.200**	

Table 5. Predictive model for prehistoric field systems based on the correlation of extant field systems with HLC Types.

Probability zone	PA	PS	Kvamme's gain	PS/PA
High	0.18	0.70	0.742	3.88
Medium	0.52	0.20	-1.608	0.38
Low	0.30	0.10	-2.037	0.33

Because the high probability zone only covers 18% of the project area and contains 70% of the sites the model is both accurate and precise and produces a high Kvamme's gain. The low probability zone also performs well, with only 10% of the sites in 30% of the project area. The weakness here is the large size of the medium probability zone – taken up entirely by Farmland Medieval. In fact this is effectively a two zone model with zones of high and low probability. This is demonstrated by the ratio of Indicative Values, which suggest the chances of encountering a field system in either the medium or low probability zones are almost equal. One is 10 times more likely to encounter an extant prehistoric field system in the high probability zone than in the medium zone - only slightly more likely than in the low probability zone.

In many respects the model for extant field systems can be regarded as largely retrodictive – modelling the pattern of known field systems – on the assumption that few field systems with surviving earth or stone remains will have escaped notice. This is particularly true of areas of Upland and Coastal Rough Ground where there has been a long history of field survey. In this respect the cropmark model has a greater capacity to predict the locations where new field systems might be found in the future.

7.3 Open settlements

Open settlements were identified by extracting from the SMR all sites interpreted as hut circle or roundhouse. After filtering to remove duplicate records the dataset contained records for 288 open settlements.

Their distribution is rather fragmented. There are two main concentrations – in West Penwith and on the fringes of the Bodmin Moor uplands. Elsewhere there are sites along the coast and a few here and there in inland areas. There are large blank areas, particularly in east Cornwall (Fig 11).

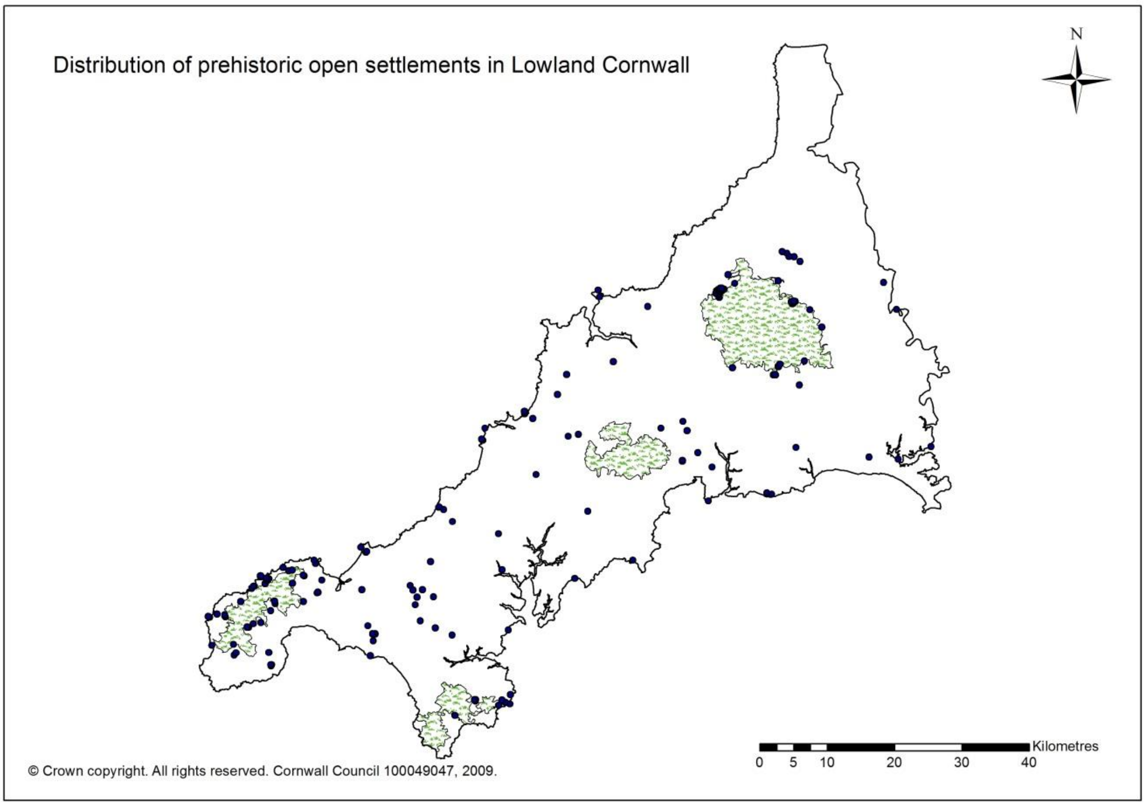

Fig 11. The distribution of open settlements in lowland Cornwall.

Plainly the settlement pattern is heavily influenced by the form of survival: although Iron Age roundhouses can sometimes form cropmark ring ditches, they are notoriously difficult to spot, even in areas of the country more conducive to cropmark formation and visibility than Cornwall (e.g. Palmer 1984, 54). In lowland Cornwall only 24 records for cropmark roundhouses are listed in the SMR whereas 70% of the sites have extant remains. Where these occur they are located within or on the fringes of Upland Rough Ground and Coastal Rough Ground.

The high level model based on the distribution of open settlements correlated with HLC Types is summarised Table 6 below.

Rank	Open settlements: High probability zone				
	HLC Type	**Sites**	**PA**	**PS**	**Kj**
1	Coastal Rough Ground	58	0.015	0.201	0.194
2	Upland Rough Ground	34	0.028	0.118	0.297
3	Farmland Prehistoric	33	0.028	0.115	0.397
4	Farmland Post Medieval	40	0.160	0.139	0.443
5	Farmland C20	27	0.108	0.094	0.468
6	Settlement C20	14	0.031	0.049	0.497
7	Military	8	0.006	0.028	0.523
8	Dunes	7	0.003	0.024	0.547
9	Plantation and Scrub	7	0.036	0.024	0.547
	Total	**228**	**0.415**	**0.792**	
	Open settlements: Medium probability zone				
	HLC Type	**Sites**	**PA**	**PS**	**Kj**
10	Farmland Medieval	55	0.522	0.191	0.216
11	Settlement older core	1	0.005	0.004	0.212

12	Water: Natural	1	0.006	0.004	0.207
13	Recreational	1	0.006	0.004	0.201
	Total	**58**	**0.539**	**0.203**	

Table 6. The high and medium probability zones of the model for open settlements.

Probability zone	PA	PS	Kvamme's gain	PS/PA
High	0.41	0.79	0.477	1.91
Medium	0.54	0.20	-1.676	0.37
Low	0.05	0.007	-5.827	0.15

All other HLC Types make up the low probability zone. The important HLC Types in the model are Coastal Rough Ground, Upland Rough Ground and Farmland Prehistoric. All three Types produce high PS/PA indicative values (ranging from 4 to 13). Of the remaining Field Types, Farmland Post Medieval and Farmland C20 (both with PS/PA values of 0.87) are of more importance than Farmland Medieval (PS/PA = 0.37), which is ranked tenth and is classed in the medium probability zone.

This model is accurate in that 79% of the sites are captured in the high probability zone and reasonably precise in that this zone covers only 41% of the project area, thereby producing a relatively high Kvamme's Gain. The low probability zone is defined precisely and accurately (less than 1% of sites in 5% of the project area). The main weakness of the model lies in the large size of the medium or neutral zone; this is due to the large size of the HLC Type Farmland Medieval. In effect the model suggests that in more than half the project area the likelihood of encountering open settlements is neither high nor low.

A probability map based on the three-zone model is shown in Fig 12 and is virtually a mirror image of that for enclosures (Fig 8). The only similarity between the two is the ranking of Farmland Prehistoric in the high probability zone of both. At face value this suggests that the nature of settlement in areas of rough ground (including the HLC Type Farmland Post Medieval, which represents former rough ground) differed from that in more intensively farmed areas, with open settlements favoured over enclosed.

A more likely alternative is that the pattern of known open settlements is heavily influenced by levels of site survival. There are an unknown and potentially large number of open settlements in parts of lowland Cornwall, particularly within areas of Farmland Medieval, which have been subjected to ploughing over a long period. Evidence for this is provided by excavations, watching briefs and geophysical surveys that have revealed hitherto undetected roundhouses (e.g. Nowakowski 1991; Jones and Taylor 2010; Gossip forthcoming). It is also worth noting that 50% of cropmark roundhouses are located in the medium probability zone (i.e. in areas of Farmland Medieval).

The likelihood that plough-levelled open settlements in lowland areas rarely produce visible cropmarks is underlined by the fact that only 8% of the open settlements in the project dataset were identified from cropmark evidence, and by the general lack of evidence from aerial photographs for roundhouses within enclosures. Given these considerations it is likely that the open settlements model ought to be regarded with scepticism.

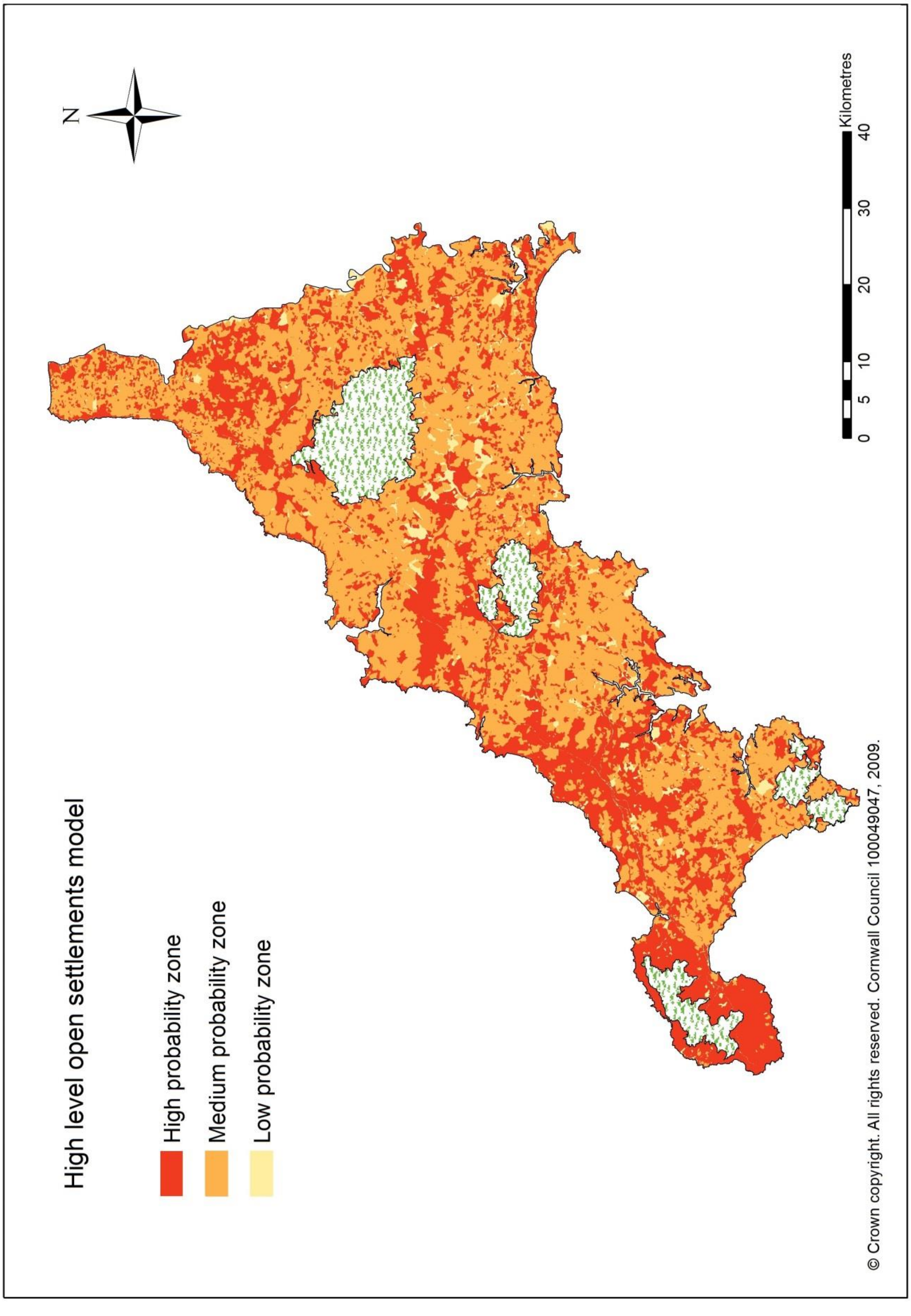

Fig 12. Probability map for the high level HLC model for open settlements.

7.4 Bronze Age barrows

In total 2,120 Bronze Age barrows are recorded in the Lowland Cornwall dataset. Their distribution is marked by dense concentrations in West Penwith, the Lizard Peninsula, the Roseland Peninsula and parts of central Cornwall, as well as by a number of other significant clusters, including linear groupings at St Breock Downs, and near Week St Mary in the northeast of the county (Fig 13).

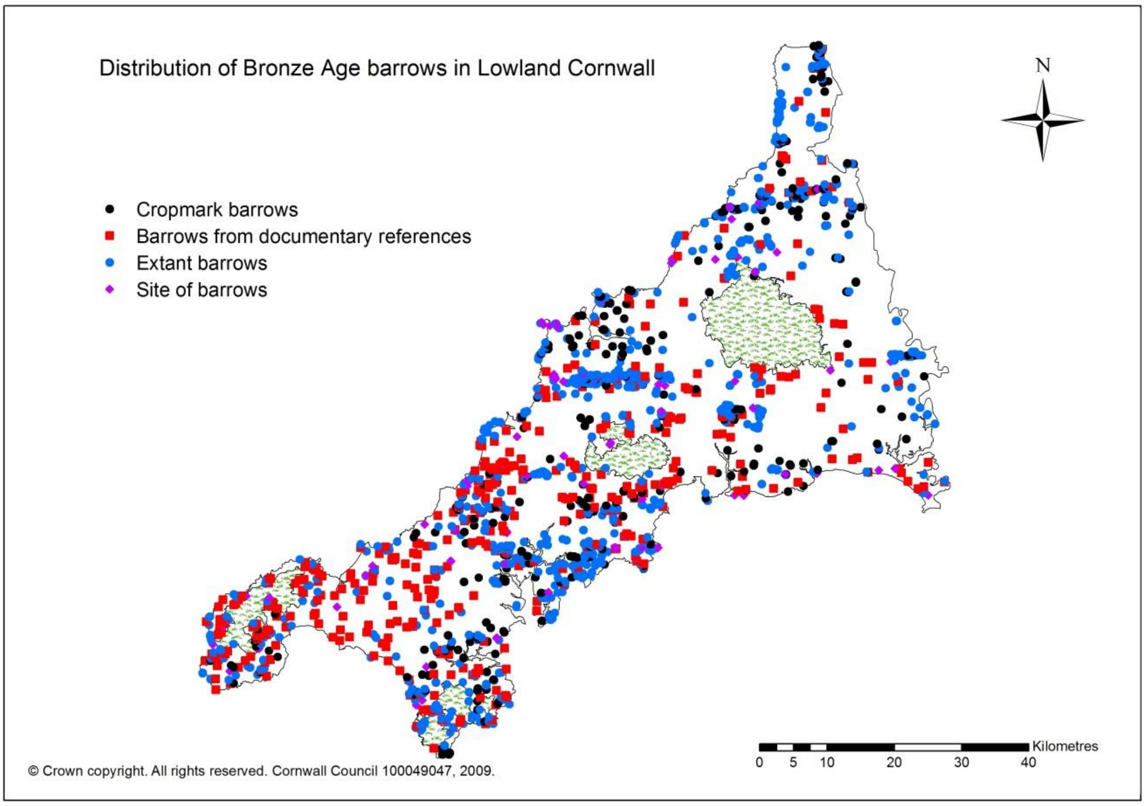

Fig 13. The distribution of Bronze Age barrows in lowland Cornwall.

More than half the barrows have above-ground extant remains, whilst only 19% are recorded as cropmarks. The majority of barrows recorded in coastal areas have above-ground remains, as do those around the Roseland peninsula, the central area, in West Penwith and on the Lizard peninsula. Of the linear groupings, those on St Breock Downs are predominantly earthworks, whilst the Week St Mary group contains a mixture of cropmark and extant sites.

The high level model based on the distribution of barrows correlated with HLC Types is summarised in Table 7 below.

	Bronze Age barrows: High probability zone				
Rank	**HLC Type**	**Sites**	**PA**	**PS**	**Kj**
1	Farmland Post Medieval	633	0.160	0.299	0.204
2	Farmland C20	324	0.108	0.153	0.288
3	Coastal Rough Ground	114	0.015	0.054	0.335
4	Upland Rough Ground	85	0.028	0.040	0.357
5	Farmland Prehistoric	83	0.028	0.039	0.379
6	Settlement C20	59	0.031	0.028	0.386
	Total	**1,298**	**0.37**	**0.613**	

	Bronze Age barrows: Medium probability zone				
Rank	HLC Type	Sites	PA	PS	Kj
7	Farmland Medieval	684	0.522	0.323	0.203
8	Rough Ground/Industrial	19	0.001	0.009	0.221
9	Recreational	22	0.006	0.010	0.231
	Total	**725**	**0.529**	**0.342**	

Table 7. The high and medium probability zones of the high level model for Bronze Age barrows.

Probability zone	PA	PS	Kvamme's gain	PS/PA
High	0.37	0.61	0.397	1.66
Medium	0.53	0.34	-0.547	0.65
Low	0.10	0.05	-1.224	0.45

The HLC Type containing the highest number of barrows is Farmland Medieval (684). However, whilst this HLC Type contains 32% of the total number of barrows, because it covers 52% of the project area it produces a low Indicative Value (PS/PA) of 0.62 and is ranked in the medium probability zone. The most important HLC Types in the model are Farmland Post Medieval and Farmland C20. Although these Types contain fewer barrows than Farmland Medieval, because they are less extensive they produce high PS/PA indicative values (1.9 and 1.4 respectively). So, for instance, Farmland Post Medieval contains almost 30% of the barrows but only covers 16% of the Lowland Cornwall area. The Rough Ground Types are also important, alongside Farmland Prehistoric.

The high probability zone has a reasonable Kvamme's Gain measure and is precise, with 61% of sites captured in 37% of the project area, but not as accurate as the other models. The low probability zone is accurately and precisely identified, with only 5% of sites contained in 10% of the project area. The ratio of Indicative Values (PS/PA) indicates that the chance of encountering a site in the high probability zone is 2.5 times higher than in the medium probability zone and 3.6 times higher than in the low probability zone. The chance of encountering a site in the medium probability zone is 1.4 times higher than in the low probability zone.

The weakness of the model is the large size of the zone of medium probability which covers more than half of the project area (Fig 14). In effect the model indicates that in more than half the project area there is neither a high nor a low probability of encountering Bronze Age barrows.

Clearly this model contrasts with, for instance, that of the enclosures in that Farmland Post Medieval and the Rough Ground Types form the zone of high probability and Farmland Medieval is only ranked ninth according to the Kj parameter formula.

This probably owes something to differential rates of monument survival in the various HLC Types. More than two thirds of the extant barrows are located in the high probability zone, whilst the medium probability zone, formed almost entirely by Farmland Medieval, has been subjected to intensive ploughing over time and the likelihood of extant monument survival here is much lower - only 31% of the barrows are recorded as extant. By contrast 47% of cropmark barrows are located in this zone. On the other hand a comparable number of cropmark barrows (44% of the total) are located in areas of Farmland Post Medieval and Farmland C20. Much of this land has only undergone intensive ploughing in more recent times and therefore one can assume a greater level of below-ground survival of archaeological deposits here compared with areas of Farmland Medieval. Moreover the area covered by Farmland Post Medieval and Farmland C20 makes up only approximately 27% of lowland Cornwall and the model suggests that these HLC Types are where barrows, including cropmark barrows, are most likely to be found.

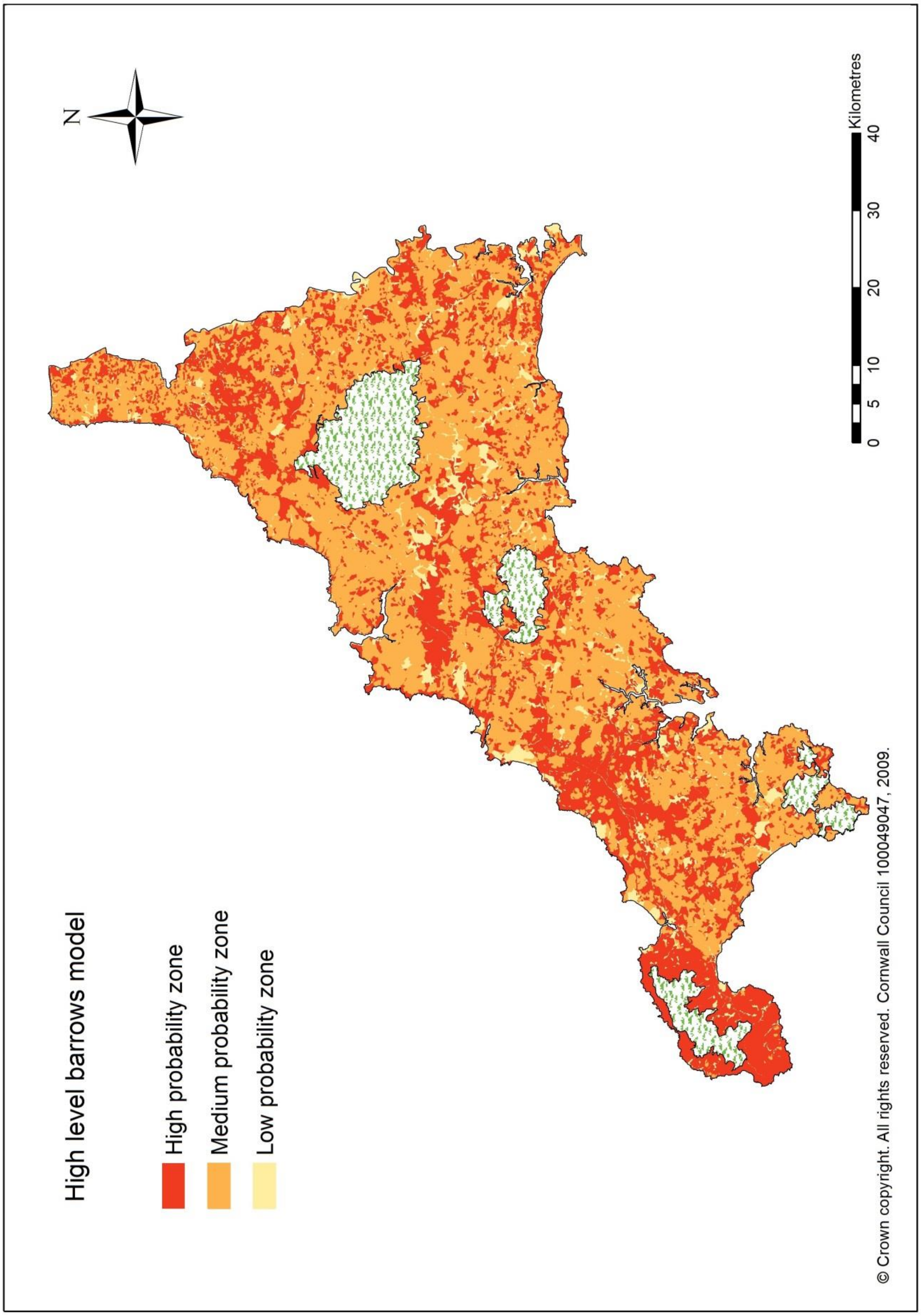

Fig 14. Probability map for the high level HLC model for Bronze Age barrows.

7.5 Early medieval settlements

A model for early medieval settlements was made in order to provide a comparison with the prehistoric/Romano-British enclosures model (Fig 15). Of the 2,116 early medieval monument records in the Lowland Cornwall dataset, 1,486 are for settlements. Of these, 1,454 (98%) are identified from documentary evidence. In almost every case, documentary records take the form of place-name evidence – in particular, Cornish place-names with the prefix *Tre-* (farmstead) and *Bod-* (dwelling). There are broad similarities between the distribution of early medieval settlements and that of enclosures, in that there is a notable bias towards western and central areas at the expense of east Cornwall. However, given that the east of the county has some of the best farmland and is unlikely to have been devoid of settlement, the lower number of recorded settlements can be explained in part by the predominance of English place-names here. The consequent paucity of Cornish place-names within this area means fewer settlements can be confidently ascribed early medieval origins.

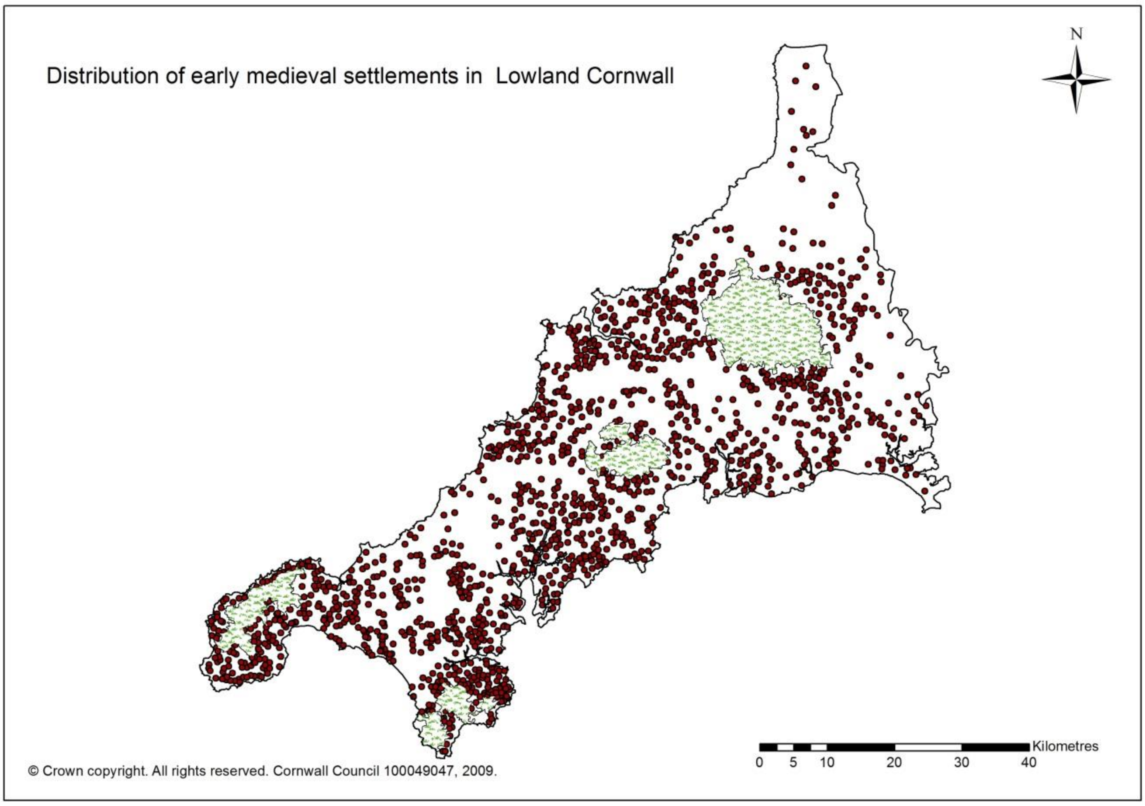

Fig 15. Distribution of early medieval settlements in lowland Cornwall.

The high level model based on their distribution correlated with HLC Types is summarised in Table 8 below.

Early medieval settlements: High probability zone				
HLC Type	**Sites**	**PA**	**PS**	**Kj**
Farmland Medieval	977	0.522	0.658	0.299
Farmland Prehistoric	116	0.028	0.078	0.370
Settlement C20	107	0.031	0.072	0.429
Ornamental	37	0.014	0.025	0.446
Total	**1,237**	**0.593**	**0.833**	

Early medieval settlements: Medium probability zone				
HLC Type	**Sites**	**PA**	**PS**	**Kj**
Farmland C20	80	0.108	0.054	0.405
Settlement older core	17	0.005	0.011	0.414
Plantation and Scrub	27	0.036	0.018	0.398
Recreational	13	0.006	0.009	0.403
Communications	10	0.004	0.007	0.408
Total	**147**	**0.159**	**0.099**	

Table 8. High and medium probability zones of the high level model for early medieval settlements in lowland Cornwall.

Probability zone	PA	PS	Kvamme's gain	PS/PA
High	0.594	0.832	0.287	1.40
Medium	0.159	0.099	-0.611	0.62
Low	0.247	0.069	-2.599	0.28

The HLC Type containing by far the highest number of settlements is Farmland Medieval (66% of all settlements). Other important HLC Types in the model are Farmland Prehistoric, Settlements C20 (where the original settlement has expanded; for instance an early medieval hamlet which has grown into a village) and Ornamental. Whilst Farmland C20 contains a significant number of settlements, it is ranked in the medium probability zone because it covers a much larger area than, for example, the HLC Type Ornamental, which occupies only a small proportion of lowland Cornwall. Farmland Post Medieval is ranked in the low probability zone.

Despite the modest Kvamme's gain this model as a whole performs rather well. It is accurate in that 83% of the settlements are captured in the high probability zone; the medium probability zone is the smallest of the three, covering only 16% of lowland Cornwall and capturing only 10% of settlements; the low probability zone, whilst covering almost a quarter of the project area, contains only 7% of the settlements.

The model clearly validates Cornwall's 1994 HLC as the vast majority of early medieval settlements are located within the Farmland Medieval HLC Type. Of course this is a somewhat circular conclusion because in defining the attributes of Farmland Medieval during the characterisation project of 1994 the following criteria were used: 'The agricultural heartland, with farming settlements documented before the 17th century AD (source, Institute of Cornish Studies place-names index)' (Herring 1998). As noted above, the vast majority of early medieval settlement records in the dataset are derived from documentary evidence, so it would be a major surprise if the model did not conform closely to HLC. The probability map based on this model is shown in Fig 16.

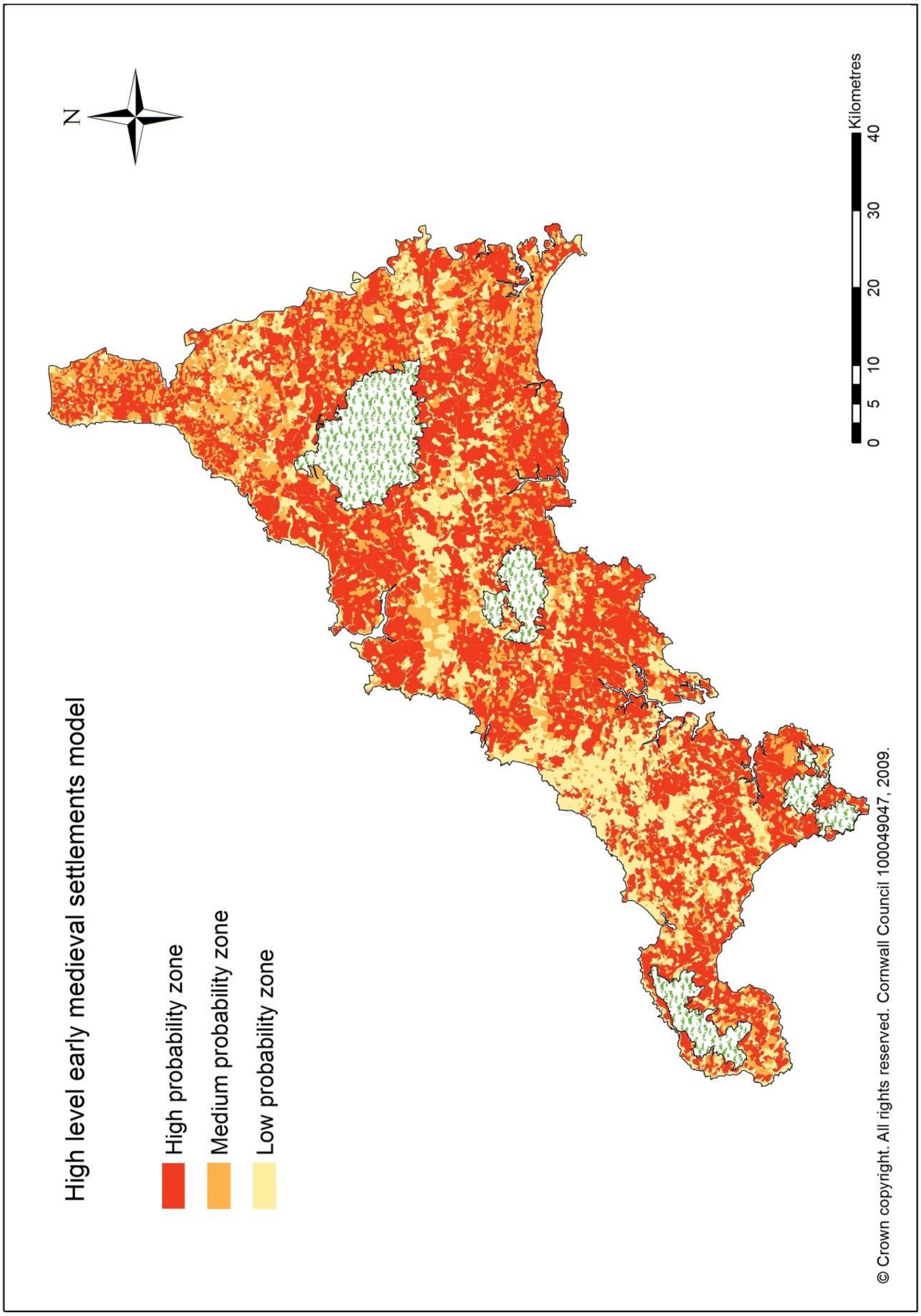

Fig 16. Probability map for the high level HLC model for early medieval settlements.

7.6 Prehistoric and Romano-British find spots

SMR data for find spots was filtered in two ways to deal with the extensive multiple-indexing of site records. First the raw dataset was rationalised by removing all multiple-indexing, resulting in a revised dataset containing one point per site. Second the raw data was analysed by period to produce a series of datasets (one for each period) which were then rationalised by removing multiple-indexing resulting from more than one type of object of the same material being recorded. Thus in cases where, for instance, records existed for a flint core and for a flint scraper at the same site this was reduced to one point for a flint find spot. Full details of how the find spot data was filtered were contained in Lowland Cornwall Volume 1, 23–24.

In total the dataset contained 1,872 records for prehistoric and Romano-British find spots reduced to a single point per site. Their distribution is shown in Fig 17.

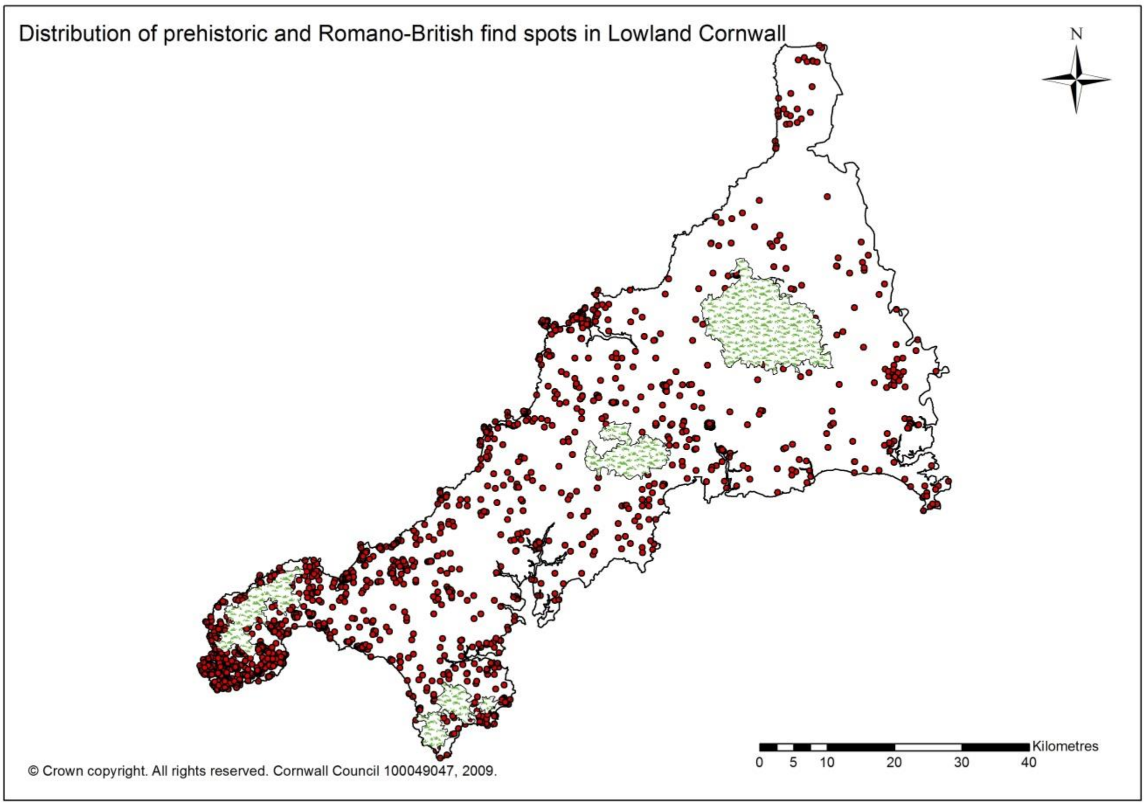

Fig 17. The distribution of prehistoric and Romano-British find spots in lowland Cornwall.

There are notable concentrations of find spots in West Penwith, on the Lizard Peninsula and at certain locations along the north coast. In general there are fewer find spots in east Cornwall than elsewhere. Gaps in the distribution may, however, in part be caused by biases in collection and the preferences of field walkers for certain sites/areas.

The model for prehistoric and Romano-British find spots is set out in Table 9 below.

	Prehistoric and Romano-British find spots: high probability zone				
Rank	**HLC Type**	**Sites**	**PA**	**PS**	**Kj**
1	Farmland Prehistoric	306	0.028	0.164	0.149
2	Coastal Rough Ground	172	0.015	0.092	0.233
3	Farmland Post Medieval	292	0.160	0.156	0.293
4	Farmland C20	200	0.108	0.107	0.328
5	Settlement C20	108	0.031	0.058	0.368
6	Upland Rough Ground	86	0.028	0.046	0.396
7	Dunes	42	0.003	0.022	0.419
8	Settlement older core (pre- 1907)	23	0.005	0.012	0.428
9	Water: Natural	14	0.006	0.008	0.432
10	Recreational	12	0.006	0.006	0.434
	Total	**1,255**	**0.390**	**0.671**	
	Prehistoric and Romano-British find spots: low probability zone				
	HLC Type	**Sites**	**PA**	**PS**	**Kj**
11	Farmland Medieval	529	0.522	0.283	0.200
12	Ornamental	17	0.014	0.009	0.190
13	Industrial: Disused	9	0.004	0.005	0.193
14	Water: Reservoirs	7	0.001	0.004	0.201
15	Ancient Woodland	20	0.022	0.011	0.171
16	Military	6	0.006	0.003	0.165
17	Communications	5	0.004	0.003	0.160
18	Industrial: Working	2	0.002	0.001	0.159
19	Rough Ground/Industrial	1	0.001	0.001	0.157
20	Plantation and Scrub	21	0.036	0.011	0.000
	Total	**617**	**0.612**	**0.331**	

Table 9. High level model for prehistoric and Romano-British find spots reduced to a single point per site.

The result is presented here as a two-zone model. It might be considered valid to define a medium probability zone as consisting of the HLC Type Farmland Medieval alone because more find spots are found within this Type than any other. However, the 529 sites constitute only 28% of the total number of find spots and, given that Farmland Medieval covers 52% of the project area, these figures represent a negative prediction. Based on the cumulative Kj values (which increase to 0.434 [Recreational] and then fall sharply to 0.20 [Farmland Medieval] and do not fall sharply again) a two-zone model more accurately reflects the outcome of this correlation.

The highest ranked HLC Type is Farmland Prehistoric (16% of all find spots in less than 3% of the project area). Other important HLC Types in the model are Coastal Rough Ground, Farmland Post Medieval, Farmland C20, Settlements C20 and Upland Rough Ground. The performance of the model is summarised below.

Probability zone	PA	PS	Kvamme's gain	PS/PA
High	0.389	0.670	0.419	1.72
Low	0.611	0.330	-0.853	0.54

This model as a whole performs quite well. It is fairly accurate in that 67% of the find spots are captured in the high probability zone and is precise in that this zone covers only 39% of the project area, hence the reasonable Kvamme's gain. The low probability zone, whilst covering 61% of the project area contains only 33% of the find spots. The Indicative values for each zone indicate that the chances of encountering a find spot in the high probability zone are more than three times that of encountering one in the low probability zone. A probability map based on this model is shown in Fig 18 below.

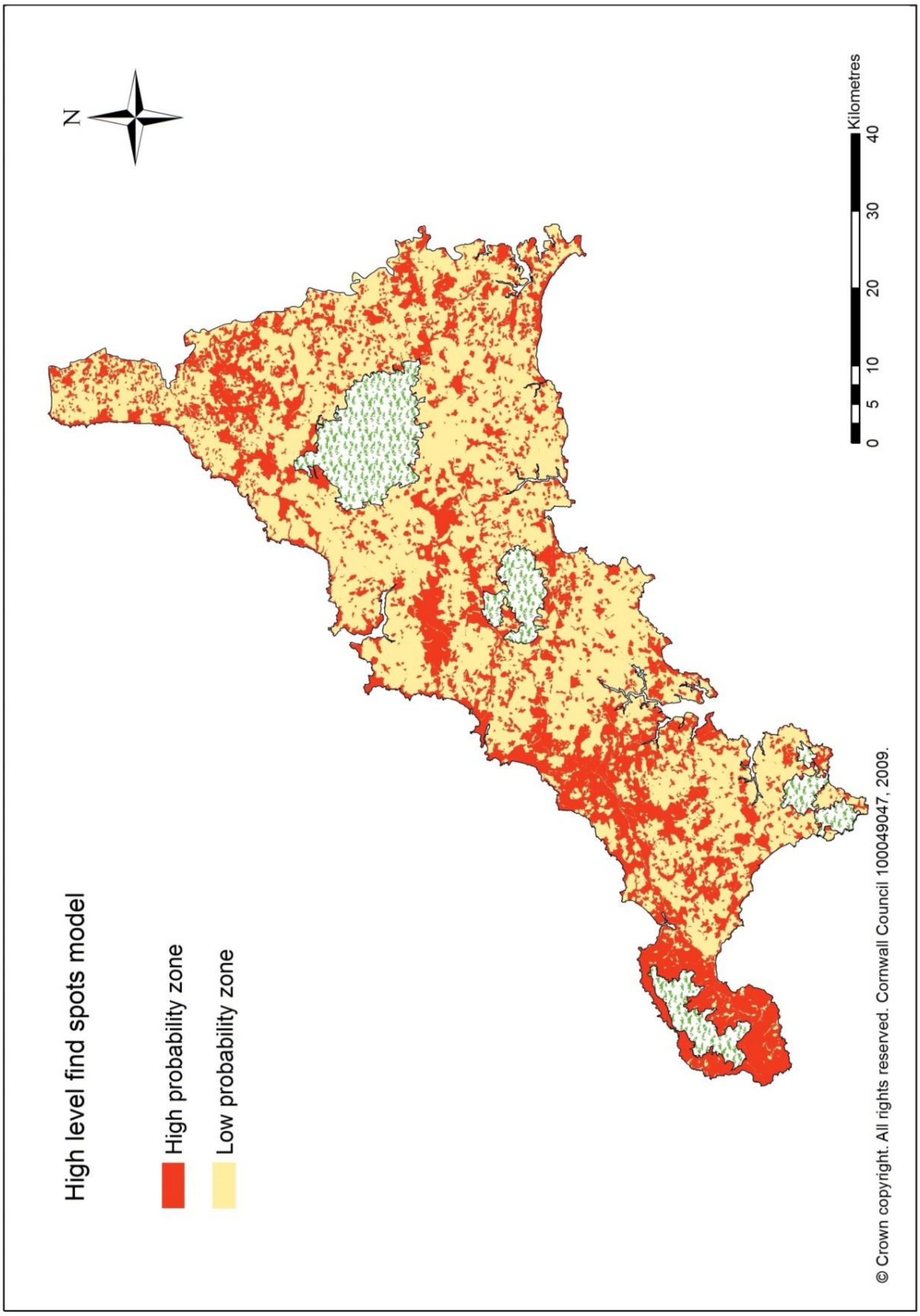

Fig 18. Probability map for the high level HLC model for prehistoric and Romano-British find spots.

The most notable aspect of the distribution of prehistoric finds is the high ranking of the HLC Type Farmland Prehistoric, which probably reflects the intensive history of finds collection which has resulted in the dense concentration of records from West Penwith. Further models were created for Mesolithic, Neolithic, Bronze Age, Iron Age/Romano-British find spots and for those allotted a generic prehistoric date. Farmland Prehistoric was ranked highest in all the models. Although the Type covers less than 3% of lowland Cornwall 16% of all prehistoric and Romano-British find spots are recorded within it, including 27% of all Mesolithic and 22% of all Neolithic finds.

The models for specific periods were fully presented in Lowland Cornwall Volume 1 (sections 8.6.2–8.6.7) but are not set out here because the make-up of their high probability zones are very similar to that of all find spots, as listed in Table 9. It can be seen from this that apart from Farmland Prehistoric the highest-ranked Types are all forms of rough ground or former rough ground.

An apparent anomaly inherent in the models is the low ranking of the HLC Type Farmland Medieval. This is surprising because this land class is essentially the present day agricultural heartland. It is more regularly ploughed than any other HLC Type (with the possible exception of Farmland C20) and therefore it might be expected that more field walking would have taken place here than in the other Types. However, the fact is that there has been little systematic or sustained programme of field walking in Cornwall and, as a result, the dataset is likely to be prejudiced towards the sphere of activity and interest of individual finds collectors. Certain locations have been subject to intensive survey, whilst others have received none at all. Furthermore, within those areas where finds collection has taken place, factors such as access to land will have further skewed the picture.

In addition to the 1,872 find spots modelled here, 231 recorded in the Portable Antiquities Scheme were included in the Lowland Cornwall dataset; their distribution also very much reflects this type of bias (see Lowland Cornwall Volume 1, 98–00). Most of the records result from the activities of a small number of finds collectors at favoured locations, of which very few are in east and southeast Cornwall. In fact the PAS finds come from only 54 sites, most of which have been visited on more than one occasion, and include some flint artefacts and a small amount of pottery, but the bulk is made up of metal objects (for instance, 148 finds of coins).

So whilst the find spots model underlines the importance of rough ground and former rough ground in the prehistoric landscape, it is based on a dataset which is almost certainly biased towards the areas of research of a small number of active finds collectors and should therefore be regarded with a good deal of circumspection.

Another weakness of the models is that each find spot is treated equally. This is especially pertinent in the case of flint assemblages, which make up the bulk of the record. A chance find of one or two flakes and a much larger and more informative assemblage have both been counted equally. Nor does the dataset include any analysis of assemblages to differentiate between the nature of the find spots and what activities may have been taking place at each site.

One curiosity of the models is the inclusion in the high probability zone of the models of the HLC Type Water: Natural. The finds from these Types are all from beaches or cliff faces and hint at slight inaccuracies in defining the 1994 HLC polygons or, alternatively, at imprecisely recorded finds locations. It might be more satisfactory to regard these finds as coming from Coastal Rough Ground.

8 Testing the models

The Cornwall and Isles of Scilly Events Record was analysed with the aim of quantifying the extent and character of below-ground prehistoric and Romano-British archaeology identified by archaeological interventions, particularly resulting from development-led work. Much of this archaeology is not yet recorded in the SMR and therefore provided a useful independent data sample with which to test the models developed during the project.

8.1 Methodology

At the time of the analysis (July 2009), the Events Record contained details of 3,694 individual interventions. The dataset was filtered to include only those Events with the potential for recording below-ground remains from the relevant periods. The appropriate types of Events are excavations, watching briefs, geophysical surveys and environmental sampling. A large number of Events such as desk-based evaluations, walk-over surveys, building surveys and mine shaft-capping works were excluded. Full details of the filtering process were contained in Lowland Cornwall Volume 1, section 9.1. As a result of this process the Events dataset analysed during the project contained details of 424 individual interventions.

These 424 events comprised the following event types:

Excavation (including test pits and evaluation trenches)	153
Watching briefs	121
Geophysical survey	141
Other (environmental, field walking, bore-hole survey, etc.)	9

The report or publication for each Event Record was studied to extract details of all the sites listed within it. New polygons for each Event were created using the field boundaries marked on current OS maps as the polygon boundaries. The reasoning behind this was that although an Event may examine only a portion of a field (for instance through the excavation of a single trench within it) material found during the Event is indicative of archaeological activity likely to extend beyond the confines of the immediate area examined. If, for example, pottery sherds were found in one trench, it is likely that further trenches dug elsewhere in the same field would uncover more sherds.

Each Event was assigned a category designed to distinguish at a general level between the types of the recorded remains. The categories were defined as follows:

1. No features or finds in an area where archaeological levels were reached and no later disturbance had occurred.
2. Unstratified finds.
3. Discrete archaeological features with no dating evidence (such as gullies, pits and apparently random post holes, which are potentially prehistoric).
4. Discrete archaeological features with dating evidence.
5. Coherent arrangements of structural features with dating evidence and site plan.

In practice although some polygons created during the analysis represent a single field, many enclose a number of adjoining fields where archaeological material had been recorded. It will be appreciated that the analysis of Events produced many more polygons than the number of actual events. The route of a pipeline (a single Event) might cut through 100 fields and be represented by 30 polygons which may fall into several of the categories outlined above. Furthermore, some fields might contain more than one category of Event. An excavation of an Iron Age enclosure may also reveal Neolithic pottery and a Bronze Age pit: in this instance three sets of attributes would be created for the field in question (it would effectively be represented by three separate polygons).

In total 833 polygons were created for the 424 individual Events making up the Lowland Cornwall dataset. However, a further issue to be addressed when using the Events data as a test sample is that in a number of cases more than one Event has taken place at the same location. The most frequent occurrence of this is where a geophysical survey is followed by a watching brief and/or excavation. At Tremough, Penryn, for instance a total of nine individual Events were carried out over a period of several years at this extensive multi-period settlement site.

At sites such as Tremough, the polygons defining these Events overlap and overlay each other and this made it difficult to calculate the extent of the site. The sum of the area covered by all nine polygons in the case of Tremough was 44.5ha, but because of the degree of overlap, this is much greater than the actual area surveyed. Therefore to create a more accurate Events dataset for testing purposes, all overlapping or overlying polygons were deleted to produce a simplified dataset. In the case of Tremough, the nine polygons were reduced to four which accurately encompass the extent of the site; together these cover 26ha.

8.2 The Events dataset

After the final filtering process the events test dataset contained 694 polygons and covered a total area of 54.36 sq km (Fig 19). As can be seen in Table 10 below, category 1 Event polygons (where no features or finds were made) are the most numerous, but there are almost as many category 5 polygons (where coherent, datable features were found).

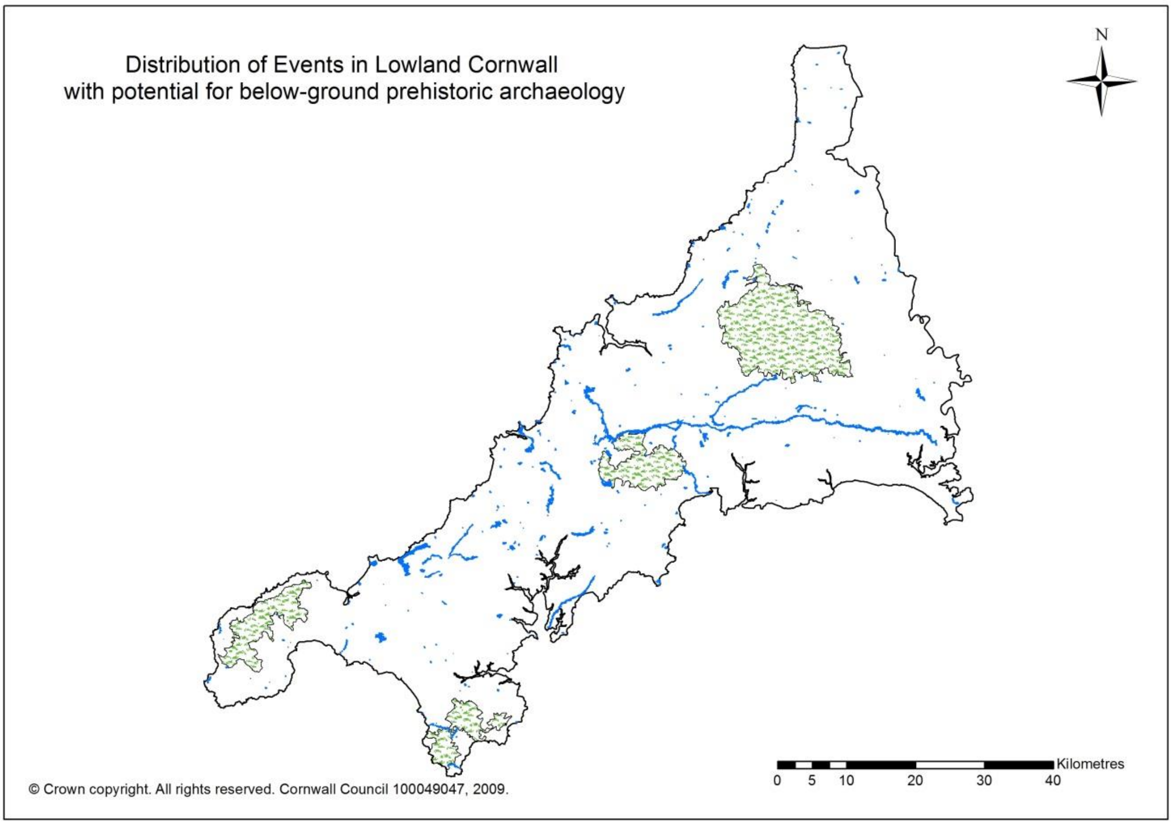

Fig 19. Distribution of Events with potential for below-ground prehistoric and Romano-British archaeology in lowland Cornwall.

Event category	No of polygons
5	141
4	97
3	142
2	119
1	195
Total	**694**

Table 10. Number of Events polygons created for each category.

8.3 Weaknesses of the Events dataset

The Events dataset contains a number of inherent weaknesses which should be acknowledged.

The dataset as a sample is rather small, covering less than 2% of the Lowland Cornwall project area. Nor is it particularly representative of the project area where the Events polygons are concerned. For instance, Farmland Prehistoric makes up 2.75% of the Lowland Cornwall project area but only 0.35% of the area covered by the Events polygons, so is under-represented in the Events dataset, whereas Farmland Post Medieval is over-represented, covering 28.07% of the Events polygons but only 16% of the Lowland Cornwall project area.

Related to this is the fact that the Events polygons were drawn using field boundaries marked on current OS maps to define their boundaries. This meant that the sizes of the polygons were dictated by the sizes of the fields, and average field sizes vary from HLC Type to HLC Type. For instance those in Farmland Prehistoric average 1.27ha whereas those in Farmland Medieval average 6.06ha. This means that 10 point data sites in Farmland Prehistoric would produce a higher PS/PA value than 10 in Farmland Medieval, which forms a far larger proportion of the survey area. Conversely 10 sites in Farmland Medieval will have on average a total area of 606 ha, whereas 10 sites in Farmland Prehistoric will have a total area of only 127 ha. This is the reason why there are differences between the results of testing with point data and area data in some of the tests (see section 8.5 below). To an extent, of course, the differences between the results of testing using point data and area can be aggregated by considering the PS/PA outcomes of both tests.

Notwithstanding these caveats, the Events Record dataset does provide a useful test sample which can be expected to provide some measure of the veracity of the models. Furthermore, the distribution of the Events reflects a good spread of sites across the whole project area (Fig 19).

8.4 Analysis of the Events and model testing

The Event polygons were intersected with the HLC Types. In many cases the Events polygons intersected more than one Type and in total the Events/HLC layer comprised 1,248 individual polygons. Centroid points were created for each of the polygons so that the data could be analysed by numbers of sites (points) or by site area (polygons). The layer could be interrogated on the basis of Event category, site type, period, HLC Type or any combination of these attributes. A breakdown of numbers of site types and the polygons containing them is set out in Table 11 below.

Site type	No of features (points)	No of polygons
Enclosure	76	93
Open settlement	73	86
Field system	28	36
Barrow	55	54
Prehistoric/RB finds	146	215
Early medieval features/finds	69	69

Medieval features/finds	246	284
No features or finds	295	411
Total	**988**	**1248**

Table 11. Breakdown of the number of sites and polygons contained in the Events/HLC GIS layer.

An important aspect of the lowland Events layer is that sites in only 281 of the polygons (22.5%) are recorded in the SMR. This meant that the remaining 967 Events polygons could be used as an independent set of data with which to test the models. When using the Events dataset as a test sample, differences between the proportion of each HLC Type making up the Lowland Cornwall area and the proportion of each HLC Type making up the area surveyed by the Events had to be taken into account. For instance, whereas Farmland Post Medieval formed 15.99% of the Lowland Cornwall project area it formed 28.07% of the area surveyed by the Events. Farmland Prehistoric, on the other hand, covered 2.75% of lowland Cornwall but only 0.35% of the Events area.

The simplest way to compensate for this variance was to calculate the S/A value - the number of sites per sq km - for each of the model's probability zones. The area (in sq km) making up each zone in the test survey area was then multiplied by the S/A value from the original model to arrive at a notional predicted number of sites for each zone. From these notional figures the predicted PS value for each zone of the test survey area was defined. This is illustrated below using the enclosures model as an example; the S/A values were calculated from the model as follows:

Probability	AREA	SITES	S/A
High	2,094.5	1551	0.74
Medium	558.36	268	0.48
Low	537.02	138	0.26
Total	3,189.88	1957	0.61

So, for the high probability zone in the test sample area the expected density of sites was 0.74 per sq km and, given that this zone covered 31.96 sq km, the notional number of sites predicted to be captured in this zone is 31.96 x 0.74 = 23.65. In total we can expect, in theory, 33.23 enclosures to be recorded in the test sample and the proportion of these falling within the high probability zone will be 23.65/33.23 = 0.71 (table 12 below).

Zone	Area sq km	S/A	Notional sites	Predicted PS
High probability	31.96	0.74	23.65	0.71
Medium probability	17.05	0.48	8.18	0.25
Low probability	5.35	0.26	1.39	0.04
Total	**54.36**	**0.61**	**33.23**	1.00

Table 12. Method for Calculating the predicted PS (proportion of sites) for each probability zone of the enclosures model using the Events as a test sample.

8.5 Test results

All the models for monument types were tested but not the find spots model as find spots generally arise from a different set of processes than finds made during excavation or other forms of archaeological intervention. The outcome of each of the tests is outlined below.

8.5.1 The enclosures model

In the Events dataset 76 sites were interpreted as enclosures. Of these one is firmly dated as Bronze Age, seven as Iron Age, 32 as Iron Age/Romano-British, 12 as

Romano-British, 16 as 'Prehistoric' and eight as 'undated' (the results of features revealed by geophysical surveys which were interpreted as likely to be prehistoric).

Forty three of the enclosures were already recorded in the SMR and 33 were new sites. This data was used as a sample to test the enclosures HLC model in two ways. Firstly the whole dataset was used (as a largely internal test sample) and then the new sites alone were used as an independent test sample. Each test was carried out twice; first with sites represented by point data, and secondly with sites represented by polygons, thereby basing the test on site density as well as the area taken up by the sites.

When the test was carried out using all 76 enclosures a close fit was achieved: it was predicted that 54 enclosures would be captured in the high probability zone and in the event this zone captured 52. The main element of inaccuracy is the better than predicted performance of the low probability zone, in which seven enclosures were captured rather than the three predicted. The most likely cause is an inherent bias in the Events sample: six of the seven sites from the low probability zone are recorded in the SMR and it is likely that these Events took place in response to developments affecting these known sites.

It should also be acknowledged that the low probability zone will always be the least stable zone in a model because for each site recorded from it an exponential number of sites must be recorded from the other zones in order to maintain the model's integrity. In other words, a site recorded from the low probability zone will have a more destabilising effect on the model than one from the medium or high probability zones. Nonetheless this is still a good result.

The test result based on area of sites worked even better. The inaccuracies relating to the low probability zone vanished and the high probability zone performed better than predicted, with a PS value of 0.72. In fact this test suggests that the model is largely correct.

On one level this is to be expected because more than half the sites in the dataset are recorded in the SMR and therefore were part of the dataset used to formulate the original model. The tables below show the results of testing the model using only the 33 previously unrecorded sites.

Zone	Area sq km	SA	NS	Predicted PS	PS	Predicted Sites	Sites
High probability	31.96	0.74	23.65	0.71	0.73	24	24
Medium probability	17.05	0.48	8.18	0.25	0.24	8	8
Low probability	5.35	0.26	1.39	0.04	0.03	1	1
Totals	**54.36**	**0.61**	**33.23**	**1.00**		**33**	**33**

Table 13. Results of events record testing of the enclosures model: test based on numbers of sites. NS = notional number of sites predicted.

Zone	Area sq km	Predicted PS	PS	Predicted site area	Site area
High probability	31.96	0.71	0.79	112.51	125.30
Medium probability	17.05	0.25	0.20	38.93	31.85
Low probability	5.35	0.04	0.01	6.62	0.90
Totals	**54.36**			**158.06**	**158.06**

Table 14. Results of events record testing of the enclosures model: test based on site area.

The test based on number of sites fits perfectly with the enclosures HLC model. In fact the high probability zone performs slightly better than predicted (with a PS value of 0.73 rather than 0.71).

When the test is carried out based on site area, the high probability zone performs better than predicted at the expense of both the other zones.

Overall the model performs best (whether the test is based on point data or site area) when tested with the new sites. Testing using site area tends to enhance the performance of the high probability zone compared with testing using site numbers. It is unclear which test is the more objective but on this evidence, it can be concluded that the enclosures HLC model is largely accurate.

8.5.2 The open settlements model

Seventy three open settlements were recorded in the Events Record. These ranged from single roundhouses to quite extensive groups of houses and other structures accompanied by pits, ditches and postholes. Frequently these settlements were located adjacent to, or in the vicinity of, enclosures. For sites where no excavation had taken place (especially those where the evidence was based solely on geophysical survey anomalies) the interpretation of features as open settlements was somewhat subjective, and the dataset should be regarded as indicating those sites which were definitely, probably or possibly open settlements.

One site was dated as Mesolithic, two as Neolithic, nine as Bronze Age, eight as Iron Age, 15 as Iron Age/Romano-British, 29 as 'prehistoric' and seven as undated but likely to be prehistoric.

It was predicted that 60 out of all 73 sites would be captured in the high probability zone, but when the test was carried out only 29 were captured. The majority, 38, were captured in the medium probability zone, as opposed to the 13 predicted. When the test was carried out based on area, the medium probability zone again performed better than predicted at the expense of the high probability zone (with a PS value of 0.60 as opposed to the predicted 0.18).

When the tests were run using only the 40 newly identified sites from the Events dataset the performance of the model was even worse.

Zone	Area sq km	SA	NS	Predicted PS	PS	Predicted Sites	Sites
High probability	25.23	0.173	4.31	0.82	0.25	33	10
Medium probability	27.50	0.034	0.94	0.18	0.63	7	25
Low probability	1.63	0.013	0.03	0.00	0.12	0	5
Totals	**54.36**		**5.27**			**40**	**40**

Table 15. Results of events record testing of the open settlements model: test based on numbers of previously unrecorded sites. NS = notional number of sites predicted.

Zone	Area sq km	Predicted PS	PS	Predicted site area	Site area
High probability	25.23	0.82	0.17	140.72	29.89
Medium probability	27.50	0.18	0.77	30.51	131.99
Low probability	1.63	0.00	0.06	0.82	10.17
Totals	**54.36**			**172.05**	**172.05**

Table 16. Results of events record testing of the open settlements model: test based on site area for previously unrecorded sites.

In both cases the model is clearly rejected by the test sample, with less than a third of the predicted number of sites captured in the high probability zone. In fact the test suggests that the position in the model of the high and medium probability zones ought to be reversed, with the high probability zone capturing only a quarter of the new sites and only 17% of its area taken up by these sites.

The poor performance of the model may be due in part to the low number of sites in the original dataset (only 288). However, analysis of the Events data suggests that the main cause of gross error is the high proportion of sites recorded from the HLC Type Farmland Medieval (which is ranked in the medium probability zone of the model) in the test sample. In fact the distribution of new sites listed in the Events Record has more in common with the enclosures HLC model.

For this reason the Events Record sample was tested against the enclosures model. For this test the open settlements were treated as if they were enclosures and therefore the sites per sq km values used to calculate the predicted number of sites and predicted PS were those of the enclosures model (i.e. 0.74 for the high probability zone and 0.48 and 0.26 for the medium and low probability zones respectively). The test was carried out using only the 40 previously unrecorded settlements and the results are shown below.

Zone	Area sq km	SA	NS	Predicted PS	PS	Predicted Sites	Sites
High probability	25.23	0.74	23.65	0.71	0.65	28	26
Medium probability	27.50	0.48	8.33	0.25	0.23	10	9
Low probability	1.63	0.26	1.31	0.04	0.13	2	5
Totals	**54.36**		**33.29**	**1.00**		**40**	**40**

Table 17. Results of events record testing the distribution of open settlements against the enclosures model: test based on numbers of previously unrecorded sites.

Zone	Area sq km	Predicted PS	PS	Predicted site area	Site area
High probability	25.23	0.71	0.79	122.23	136.73
Medium probability	27.50	0.25	0.15	43.04	25.16
Low probability	1.63	0.04	0.06	6.79	10.17
Totals	**54.36**			**172.05**	**172.05**

Table 18. Results of events record testing the distribution of open settlements against the enclosures model: test based on site area.

The result of testing with point data shows a reasonably close fit, although the performance of the low probability zone is better than predicted. When the same test is carried out based on site area the high probability zone performs better than predicted (at the expense of the medium probability zone). The results of testing the distribution of open settlements based on site area are very similar to the result of testing the distribution of enclosures, with 79% of site area captured in the high probability zone.

Testing using point data appears to enhance the low probability zone at the expense of the high probability zone, whereas testing using site area tends to enhance the performance of the high probability zone. It is unclear which test is the more reliable but a reasonable conclusion is that the actual PS values lie somewhere between the two. Against predicted PS values of 71%, 25% and 4% for each of the probability zones, the new open settlements produced actual values of 65 – 79%, 15% - 23% and 6 - 13%.

The result of these tests is significant. The model for the distribution of open settlements based on the Lowland Cornwall dataset correlated with HLC was rejected by the test sample. Further testing demonstrated that the distribution of open settlements identified from Events conforms strongly to the model for enclosures. The implication is that the known distribution of open settlements is heavily influenced by level of survival – in other words that the pattern reflects the distribution of settlements with extant above-ground remains. The test shows that settlements with only below-ground remains surviving are generally located in similar HLC Types to enclosures – most notably the HLC Type Farmland Medieval – and the enclosures model serves as a more accurate indicator of those areas where undiscovered open settlements are most likely to be located in the future.

8.5.3 The field systems model

Twenty eight field systems were recorded in the Events dataset. One is dated to the Bronze Age, five are Iron Age/Romano-British, five are Romano-British, eight are interpreted as 'prehistoric' and nine are of unknown date but are potentially prehistoric. Eight of the field systems are potentially multi-phased. Eighteen of the field systems are new sites whilst ten were previously recorded in the SMR.

It was predicted that 23 field systems would be captured in the high probability zone and in reality 21 were captured. The medium probability zone performed exactly as predicted and the low probability zone captured two sites where none had been predicted. When the test was based on area, the medium probability zone performed better than predicted, with a PS value of 0.35 as opposed to the 0.17 predicted: this was at the expense of the high probability zone.

When the test was carried out using the sample of 18 previously unrecorded sites the results were broadly similar.

Zone	Area sq km	SA	NS	Predicted PS	PS	Predicted Sites	Sites
High probability	34.7	0.21	7.29	0.83	0.78	15	14
Medium probability	16.42	0.09	1.48	0.17	0.11	3	2
Low probability	3.24	0.02	0.06	0.01	0.11	0	2
Totals	**54.36**		**8.83**			**18**	**18**

Table 19. Results of events record testing of the field systems model: test based on numbers of new sites.

Zone	Area sq km	Predicted PS	PS	Predicted site area	Site area
High probability	34.70	0.83	0.70	79.59	67.04
Medium probability	16.42	0.17	0.28	16.14	27.03
Low probability	3.24	0.01	0.02	0.71	2.38
Totals	**54.36**			**96.44**	**96.44**

Table 20. Results of events record testing of the field systems model: test based on site area for the 18 new sites.

One reason for larger than expected areas being captured in the medium probability zone is that field systems can cover extensive areas and in some cases their polygon extends over two or more HLC Types. So although their centroid may be captured in the high probability zone, part of their polygon may be captured in the medium zone. Allied to this is the fact that the polygons were drawn using present day field boundaries to define their extent. So to a degree the sizes of the present day fields dictate the sizes of the polygons. For example, whilst the point data includes only four field systems in the HLC Type Farmland Post Medieval, the total area of Farmland Post Medieval containing field systems is 40.21 ha – apparently an average size of 10.05 ha per site (by comparison those in Farmland Medieval have an average size of 5.55 ha per site).

Nonetheless, it can be concluded that the tests broadly verify the field systems model, although it is possible that the likelihood of finding field systems in the medium probability zone is understated in the original model.

8.5.4 The Bronze Age barrows model

Fifty five barrows are recorded in the Events dataset. This figure includes sites listed as barrow, barrow cemetery, cairn, burial and cist where the period is interpreted as Bronze Age. Only 11 of the barrows are new sites.

It was predicted that 38 barrows would be captured in the high probability zone and when the test was run there were actually 42 barrows in this zone. When the test was based on polygon area, again the high probability zone captured a greater proportion of the sites than expected. This was at the expense of the medium probability zone, in which the PS value was 0.20 as opposed to the 0.29 predicted. In the context of predictive models, the fact that the high probability zone performed better than expected is not in itself a bad result, and overall the model is strongly validated by the tests. However, it is to be expected as so many of the barrows in the dataset are recorded in the SMR and therefore were part of the dataset used to formulate the original model. For this reason the new sites were also used to test the model, even though 11 barrows represent a very small sample.

Zone	Area sq km	SA	NS	Predicted PS	PS	Predicted Sites	Sites
High probability	24.75	1.1	27.23	0.69	0.45	8	5
Medium probability	26.93	0.43	11.58	0.29	0.45	3	5
Low probability	2.68	0.3	0.80	0.02	0.09	0	1
Totals	**54.36**		**39.61**			**11**	**11**

Table 21. Results of events record testing of the barrows model: test based on numbers of new sites.

Zone	Area sq km	Predicted PS	PS	Predicted site area	Site area
High probability	24.75	0.69	0.47	13.42	9.12
Medium probability	26.93	0.29	0.53	5.71	10.30
Low probability	2.68	0.02	0.01	0.40	0.10
Totals	**54.36**			**19.53**	**19.53**

Table 22. Results of events record testing of the barrows model: test based on site area for the 11 new sites.

This test produced a very different result. Five of the barrows are located in the HLC Type Farmland Medieval, three are in Farmland Post Medieval and one in each of Communications, Recreational and Upland Rough Ground. As a result, when the test is based on point data the high probability zone captures 45% of the barrows rather than the 69% predicted. When the test is based on polygon area the medium probability zone actually scores higher than the high zone. Both tests reject the model but, because of the small size of the test sample, this result is best treated as inconclusive.

9 The high level models: discussion

Farmland Medieval and Kvamme's Gain

The HLC Type Farmland Medieval presented difficulties to the model building process. Farmland Medieval takes up more than half of the project area and contains more sites than any other HLC Type for all site types (including find spots) apart from hut circles/roundhouses. Because of its large area this Type weakens the models regardless of the probability zone in which it sits. If it is ranked in the low probability zone then that zone will automatically capture a large number of sites and the model will not be accurate; if it is ranked in the medium probability zone then the model will have a very large neutral area (the medium probability zone should in theory be neither site-likely or site-unlikely); if the Type is placed in the high probability zone then the model will not be very precise and will produce low gain measures. To illustrate this point, let us imagine that all sites are captured in Farmland Medieval. Therefore 100% of the sites are captured in 52% of the project area. The Kvamme's Gain measure (1-[PA/PS]) will be 1-0.52 = 0.48. Therefore if Farmland Medieval equals the high probability zone the maximum gain measure this zone can score is 0.48. In the predictive modelling literature (e.g. Gibson 2005) the model would be regarded as weak.

However, a good predictive model should be both accurate and precise but the results of Lowland Cornwall show that Kvamme's Gain is really only a measure of precision. The definition of the high probability zone of all the models created during this project has been made with accuracy as the main target – wherever possible trying to capture 70% of the sites or more. Rather than using Kvamme's Gain as the only measure of performance, reference has been made to the relative performance of each zone within the models, so although the high probability zone of the enclosures model has a low Kvamme's Gain of 0.17, one is three times more likely to encounter a site in the high probability zone than in the low zone.

The models for monument types

The aim of the model building process was to construct predictive models containing three zones – for high, medium and low probability. In the event, whilst this was achievable for monument site types it was only possible to develop two zone models (indicating high and low probability) for prehistoric find spots. Essentially the three zone models can be sub-divided into two broad categories;

1. Those whose high probability zone is characterised by the HLC Types Farmland Medieval, Farmland Prehistoric and Farmland C20
2. Those whose high probability zone is characterised by the HLC Types Farmland Prehistoric, Farmland Post Medieval, Coastal Rough Ground, Upland Rough Ground and Farmland C20.

The high probability zones of the first category capture enclosures and early medieval settlements, those of the second category capture Bronze Age barrows and open settlements. The model for field systems is a 'hybrid' of the two: its high probability zone is made up of the HLC Types Farmland Prehistoric, Coastal Rough ground, Farmland Medieval, Farmland C20 and Upland Rough Ground.

To an extent it is likely that the model categories are influenced by the form of monument survival. Extant monuments are more numerous in Rough Ground and Recently Enclosed Land – the barrows and hut circles datasets are both characterised by high numbers of extant sites, and extant field systems are located primarily in Farmland Prehistoric, Coastal Rough Ground, Upland Rough Ground and Farmland C20. By contrast enclosures (more than half of which are recorded as cropmarks) are located predominantly in Farmland Medieval, Farmland Prehistoric and Farmland C20, and cropmark field systems are also found most commonly in these HLC Types.

It follows that the category 2 models may be somewhat misleading in that they are to a degree retrodictive – indicating the distribution of known sites only, rather than the likely location of previously undiscovered sites. This is perhaps underscored by the fact that when tested using new data contained in the Events Record the hut circles/roundhouse model was clearly rejected. However, when this same new data was tested against the enclosures model it achieved a much closer fit, suggesting that the real distribution pattern of open settlements is similar to that of the enclosures. The Events Record test also questioned the veracity of the barrows model, although this test was inconclusive due to the small size of the test sample.

The positions of the HLC Types Farmland Prehistoric and Farmland C20 are of considerable significance as they are the only Types to be part of the high probability zone of all the models for prehistoric monuments. Although it may seem to be stating the obvious that prehistoric monuments will be located in the HLC Type Farmland Prehistoric, the results of this project do provide a clear verification of the interpretation of this Type. Beyond this it should be borne in mind that in the 1994 HLC Farmland Prehistoric is confined to West Penwith and these models serve to underline the very rich assemblage of prehistoric sites found there, adding to the perception that in terms of its historic environment, West Penwith can be regarded as regionally distinct from the rest of Cornwall. The fact that Farmland Prehistoric is also ranked in the high probability zone of the early medieval settlements model supports the perception of continuity – the settlement zone of early medieval farmers being the same as their predecessors.

Land classed as Farmland C20 has undergone either one of two historical processes. In places this Type represents the twentieth century intake of former rough ground; in others it represents twentieth century reorganisation of earlier farmland, including former Farmland Medieval. In other words it contains elements of both model categories described above: it is characterised both by sites typical of rough ground, such as barrows and by sites typical of Farmland Medieval, such as enclosures. In this respect Farmland C20 blurs the models to some extent, reducing their precision. One of the aims of the HLC revision undertaken as part of this project was to better define these two types of Farmland C20 so that more precise models might be achieved.

Overall, the models do corroborate the assertion that in lowland Cornwall the medieval settlement and farming heartland is a continuation of the later prehistoric and Romano-British farming heartland. The models for both early medieval settlements and enclosures are similar in some important respects: the HLC Type Farmland Medieval is the highest ranked type in both models, both are accurate, capturing 83% and 79% of sites in their respective high probability zones, and both models were verified when tested with events record data. Although the model for open settlements (hut circles/roundhouses) appears to contradict this pattern, testing suggests that the locations of previously unrecorded roundhouses discovered during interventions are, for the most part, consistent with the high probability zone of the enclosures model. There is little doubt that many open settlements remain undiscovered and the inference is that their distribution is similar to that of enclosures. Farmland Prehistoric and Farmland Medieval also form part of the high probability zone of the field systems model, although this model is less clear cut in that the fields extend beyond the medieval farming heartland into HLC Types such as Coastal Rough Ground. Tellingly the model for cropmark field systems, which is likely to be most indicative of the location of currently undiscovered field systems, coincides exactly with the enclosures model – the high probability zone is formed by the HLC Types Farmland Medieval, Farmland Prehistoric and Farmland C20.

The model for Bronze Age barrows is inconclusive. Whilst the high probability zone is formed predominantly by Rough Ground and Recently Enclosed Land Types, more barrows are located in Farmland Medieval than any other HLC Type. Furthermore the majority of cropmark barrows are located within Farmland Medieval, and when tested with the very small number of new barrows from the Events Record the model was rejected, suggesting that Farmland Medieval is where most undiscovered barrows are likely to be found. On the other hand the proportion of cropmark barrows recorded in the HLC Types Farmland Post Medieval and Farmland C20 relative to the area taken up by these Types is higher than that for Farmland Medieval. So, whilst there is the potential for the discovery of more barrows in areas of Farmland Medieval, it is the Types Farmland Post Medieval and C20 where most new barrows are most likely to be found.

The models for find spots

For the find spots models there were difficulties in defining cut-off points between the probability zones and, in most cases, it was only possible to define a high and low probability zone.

For the most part the high probability zones of all the find spots models are characterised by the HLC Types Farmland Prehistoric, Coastal Rough Ground, Farmland C20, Farmland Post Medieval, Upland Rough Ground and Settlement C20.

However, no firm conclusions can be drawn from the models other than to say that the data currently held in the SMR is unlikely to be representative of the true distribution of prehistoric finds in lowland Cornwall. The distribution, for a large part, is felt likely to reflect the main areas of activity of a few finds collectors over time; a more systematic programme of field walking may help redress this bias. The skewed nature of the finds dataset is most apparent when considering Portable Antiquities Scheme data, which can more satisfactorily be treated as an Event, or series of Events, rather than a meaningful distribution.

HLC Types

Taking the models as a whole (and disregarding the find spot models) it is possible to broadly define the types of prehistoric site which might be regarded as typical of each HLC Type, taking into account not only the actual numbers of each site type within the HLC Type but also the percentage of each site type recorded within the HLC Type. So, for example, 26% of the sites recorded from Coastal Rough Ground are barrows, but only 5% of all the barrows in lowland Cornwall are located in Coastal Rough Ground. Characteristic site types for the main HLC Types are listed below.

- **Farmland C20.** Typical sites are barrows, enclosures and field systems. Early medieval settlements are rare.
- **Farmland Medieval.** Early medieval settlements, enclosures and open settlements and field systems are typical.
- **Farmland Post Medieval.** Barrows are typical. Enclosures, field systems and early medieval settlements are rare.
- **Farmland Prehistoric.** Field systems and roundhouses are typical. Early medieval settlements and barrows are less common.
- **Upland and Coastal Rough Ground.** Barrows, roundhouses and field systems are typical. Enclosures and early medieval settlements are rare.

10 The influence of environmental factors and reconnaissance patterns on cropmark visibility

Having established that HLC Types produce models which, although achieving a high degree of accuracy, are lacking in precision due to their high probability zones covering a substantial portion of the county, the next stage of the project sought ways of addressing this issue. One effect of this lack of precision was the apparent failure of the models to reflect regional variations in the known distribution of certain site types. The known locations of enclosures, for instance, are relatively sparse in east Cornwall, but the enclosures model based on HLC Types suggests that parts of east Cornwall fall within the zone of high probability.

A high percentage of the enclosures in lowland Cornwall are recorded in the SMR as cropmarks. Not all types of geology and soils are conducive to cropmark production and a likely explanation for the apparent failure of the HLC model to reflect regional variations in site distributions is that the distribution patterns are skewed by variations in underlying geology, soils and land use. It is also plain that the historical pattern of aerial reconnaissance will have influenced the likelihood of cropmarks being seen, just as variations in geology, soils and land use influence the likelihood of cropmarks being formed.

For these reasons a cropmark visibility map was produced showing those areas where cropmarks are most likely to form and where they are most likely to have been identified. Full details of how this was done were contained in Lowland Cornwall Volume 2.

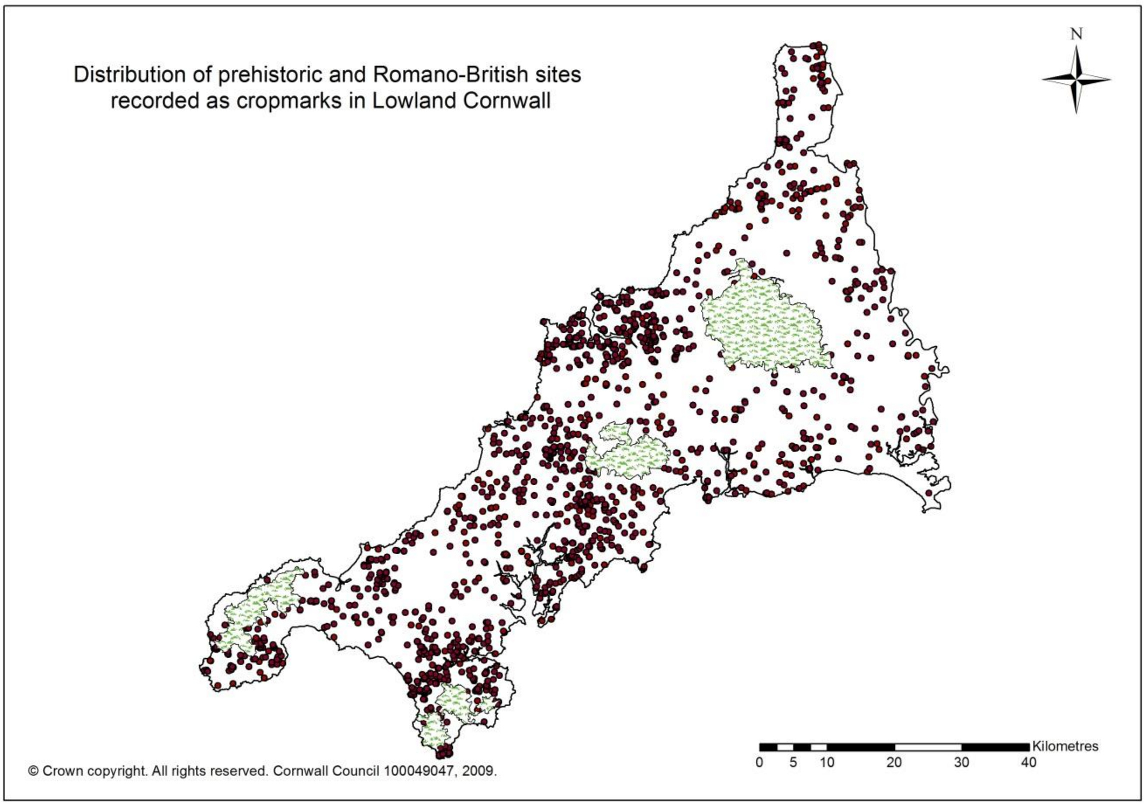

Fig 20. Distribution of prehistoric and Romano-British cropmark sites in lowland Cornwall.

The first step in this process was to display SMR point data for cropmark sites and spatially correlate this data with the relevant land classes. In total the dataset contains records for 1,759 prehistoric or Romano-British sites listed as cropmarks. Their overall distribution in lowland Cornwall is shown in Fig 20. The distribution is characterised by significant concentrations in parts of central Cornwall and the northern part of the Lizard peninsula; cropmark distribution in east and southeast Cornwall by contrast is sparse.

The cropmark dataset is dominated by enclosures, whose substantial enclosing ditches are more likely to produce visible cropmarks than the relatively slight ditches formed by field systems or the gullies of roundhouses, which are notoriously difficult to identify. This is confirmed by the fact that only 24 roundhouses are listed in the dataset. A full breakdown of site types in the cropmarks dataset is outlined in table 23 below.

Site type	No. of sites	% of total
Enclosure	1,047	59.5%
Barrow	398	23%
Field system	286	16%
Hut circle/roundhouse	24	1.3%
Hillfort	4	0.2%
Total	**1,759**	

Table 23. Breakdown of site types contained in the cropmark dataset.

10.1 Land classes used as variables

Three land classes were used as the variables for model building: Agricultural Land Class (ALC), bedrock geology and soil types. At the outset of the project the intention was also to use the 1995 Land Cover data produced by the Cornwall Wildlife Trust, showing areas of arable and improved grassland. There were, however, technical problems attempting to join SMR data with this layer and ultimately it was not possible to use it.

10.1.1 Agricultural Land Class (ALC)

This data was derived from the Agricultural Land Classification of England and Wales ALC009 (Natural England 1985). The layer contains 11 different categories, but more than 83% of the project area is covered by only two of these (Grades 3 and 4). Furthermore the polygons forming each category are highly generalised and their boundaries are consequently somewhat schematic. This strongly implied that any model derived from this layer must be judged as approximate only.

10.1.2 Soil types

The GIS soils layer was derived from the National Soil Resources Institute (2004). The classification system includes 'Simple description', comprising 25 different classes. Of these, types described as loam over shale are by far the most extensive, covering 61% of the project area; the next largest category, loam over granite, covers only 10%. These classes are sub-divided into 33 soil types listed under their 'Map unit name'. Map unit name, being more detailed, was assessed as being the most appropriate for using in model construction.

10.1.3 Bedrock geology

The GIS geology layer was based on data from the British Geological Survey (BGS). This comprised two principal elements; bedrock (solid geology) and superficial (drift geology) data. Superficial geology consists predominantly of alluvium and head deposits and is largely confined to river valleys (although there are a few more extensive alluvium deposits, for instance at Goss Moor, and some extensive deposits of blown sand, as at Perranporth). Much of lowland Cornwall is devoid of superficial deposits and therefore only the bedrock data was used for building the models.

The BGS bedrock data contains more detailed attributes than that for either soils or Agricultural Land Classification. In the classification system there are 107 different rock types listed under the classification LEX_D. Another category, RCS_D, simplifies these into 79 types and was the classification used to build the models.

One problem with BGS data was that in some places where the data tiles meet, the geology types from neighbouring tiles did not always correspond, presumably because individual surveyors interpreted the rock types differently. Despite these inconsistencies, BGS data provides a reasonably good base layer for predictive modelling purposes.

10.2 The models

The methodology used for model construction was exactly the same as for the HLC models. Chi-Squared testing found that when correlated with ALC classes, soil types and bedrock geology types, the null value was rejected in each case, indicating that the distributions are statistically significant. Models were then built using the Kj parameters to rank each ALC, soil and rock type, and to define the cut-off point for each probability zone.

10.2.1 The cropmarks/ALC model

As described above, more than 83% of the project area is covered by only two of the ALC categories. As a result the model derived from ALC data lacked any precision: 81% of the cropmarks were located in these two categories. The high probability zone was formed by ALC Grades 2, 3 and 3B and produced a Kvamme's Gain of only 0.161. The probability map based on the model suggests that cropmarks are likely to be found anywhere apart from urban areas, some coastal areas, steep-sided river valleys and high ground. Given the generalised nature of the ALC model it can be concluded that Agricultural Land Classification is unlikely to add much critical information to the question of cropmark visibility. For this reason ALC data was not included in the final cropmark visibility model.

10.2.2 The cropmarks/soil types model

When correlated with SMR data the soils layer provided a good model, details of which are outlined in Table 24 below.

Cropmarks/soils. High probability zone				
Soil type	**Cropmarks**	**PA**	**PS**	**Kj**
Denbigh 2	700	0.295	0.398	0.203
Powys	238	0.060	0.135	0.308
Moretonhampstead	159	0.073	0.090	0.349
Trusham	110	0.040	0.063	0.387
Sportsmans	48	0.018	0.027	0.402
Totals	**1,255**	**0.486**	**0.713**	**0.402**
Cropmarks/soils. Medium probability zone				
Denbigh 1	221	0.215	0.126	0.339
Neath	61	0.045	0.035	0.333
Hallsworth 1	41	0.019	0.023	0.342
Croft Pascoe	21	0.005	0.012	0.354
Yeollandpark	23	0.010	0.013	0.360
Hallsworth 2	13	0.006	0.007	0.362
Totals	**380**	**0.30**	**0.216**	**0.362**

Table 24. Make-up of the high and medium probability zones of the model for the distribution of cropmarks correlated with soils data.

All of the soil types ranked in the model's high probability zone are loams. This is to be expected because these soils are the most fertile and therefore the most likely to be currently under arable cultivation. Cereal production is most likely to take place on these soils – hence the high probability of cropmarks being observed. It is also possible that because the loams are the best soils prehistoric settlements were concentrated on them.

10.2.3The cropmarks/bedrock geology model

Details of the high and medium probability zones of this model are shown in Table 25 below.

Cropmarks/bedrock geology model. High probability zone				
Bedrock	**Cropmarks**	**PA**	**PS**	**Kj**
Slate and siltstone	328	0.153	0.187	0.079
Sandstone and [subequal/subordinate] argillaceous rocks, interbedded	213	0.075	0.121	0.157
Mudstone	84	0.013	0.048	0.202
Mudstone and sandstone	137	0.064	0.078	0.236
Mudstone, siltstone and sandstone	80	0.014	0.046	0.277
Granite	160	0.092	0.091	0.302
Slate and sandstone, interbedded	99	0.041	0.056	0.331
Sandstone	69	0.045	0.039	0.336
Hornblende schist	34	0.007	0.019	0.354
Totals	**1,204**	**0.504**	**0.685**	**0.354**
Cropmarks/bedrock geology model. Medium probability zone				
Slate, siltstone and sandstone	129	0.106	0.074	0.337
Hornfelsed slate and Hornfelsed siltstone	64	0.050	0.036	0.329
Slaty mudstone with sedimentary rock, metamorphic rock and igneous rocks	24	0.007	0.014	0.340
Microgabbro	21	0.005	0.012	0.351
Mudstone and siltstone	93	0.090	0.053	0.315
Peridotite and Serpentinite	21	0.006	0.012	0.326
Basaltic lava	10	0.005	0.006	0.328
Totals	**362**	**0.269**	**0.207**	**0.328**

Table 25. Make-up of the high and medium probability zones of the model for the distribution of cropmarks correlated with bedrock geology data.

This model does not perform quite as well as the soils model, with a Kvamme's gain of 0.266 as opposed to 0.319. A smaller proportion of sites (69% compared with 71%) is captured in the high probability zone. A higher proportion of sites are captured in the low probability zone than in the soils model (10% against 7%).

10.2.4 The cropmark/soils and bedrock geology model

Probability maps produced by the soil types and geology models share some similarities, most notably that most of the high probability zones lie in western and central areas and that large parts of east Cornwall are captured in the low probability zones. However, there are also differences. For example, the rock type granite is frequently overlain by the soil type Moor Gate and also by the soil type Moretonhampstead. Granite is classed as part of the high probability zone in the bedrock model: in the soils model Moretonhampstead is classed as part of the high probability zone but Moor Gate is placed in the low probability zone. To reconcile these differences a model based on a combination of both sets of data was produced. To do this the soils and bedrock geology layers were amalgamated. A model was then produced based on the combined polygons. The combined layer consisted of 558 different combinations of soils and bedrock geology of which 134 capture cropmark sites. The performance of the model is summarised below.

Probability	PA	PS	Kvamme's gain	PS/PA
High	0.309	0.537	0.426	1.74
Medium	0.282	0.256	-0.100	0.91
Low	0.410	0.207	-0.980	0.50

This model produces a higher Kvamme's gain than either the soils or geology models on their own. However, the high probability zone has only captured 53% of the sites and the low probability zone has captured 20% of the sites - only 5% fewer than the medium probability zone. Thus whereas this model is quite precise, it is wanting in accuracy. Despite the weaknesses of this model it best expresses the influence of all the geomorphological factors affecting the formation of cropmarks. This model was therefore taken forward and combined with the model for the pattern of aerial reconnaissance.

The probability map derived from this model is shown in Fig 21 and the combinations of geology and soil types forming the zones of high and medium probability are summarised in Table 26 below.

Cropmark/soils and bedrock geology model. High probability zone				
Bedrock description	**Soil type**	**Cropmarks**	**Kj**	**Kvamme's Gain**
Sandstone and [subequal/subordinate] argillaceous rocks, interbedded	Denbigh 2	152	0.066	0.587
Slate and siltstone	Denbigh 2	144	0.118	0.495
Granite	Moretonhampstead	141	0.157	0.400
Mudstone and sandstone	Denbigh 2	116	0.197	0.391
Slate and sandstone, interbedded	Denbigh 2	81	0.226	0.392
Slate and siltstone	Powys	71	0.258	0.415
Mudstone	Powys	65	0.293	0.448
Mudstone, siltstone and sandstone	Powys	50	0.318	0.466
Slate, siltstone and sandstone	Denbigh 2	47	0.326	0.438
Hornblende schist	Trusham	34	0.343	0.448
Hornfelsed slate and Hornfelsed siltstone	Denbigh 2	44	0.350	0.426
Totals		**945**	**2.652**	**4.906**
Cropmark/soils and bedrock geology model. Medium probability zone				
Slate, siltstone and sandstone	Denbigh 1	61	0.345	0.364
Slate and siltstone	Denbigh 1	53	0.343	0.324
Sandstone	Neath	42	0.349	0.311
Mudstone and siltstone	Hallsworth 1	39	0.359	0.308
Slate and siltstone	Trusham	29	0.371	0.312
Sandstone and [subequal/subordinate] argillaceous rocks, interbedded	Denbigh 1	28	0.373	0.301
Slaty mudstone with sedimentary rock, metamorphic rock and igneous rock clasts	Denbigh 2	23	0.384	0.307
Slate	Denbigh 1	30	0.379	0.285
Sandstone and [subequal/subordinate] argillaceous rocks, interbedded	Powys	20	0.380	0.278
Peridotite and Serpentinite	Croft Pascoe	17	0.388	0.282
Microgabbro	Trusham	15	0.397	0.288
Slate and siltstone	Sportsmans	15	0.405	0.293
Mudstone	Denbigh 2	15	0.412	0.297
Mudstone and siltstone	Neath	19	0.405	0.279
Slate	Denbigh 2	17	0.399	0.264
Granite	Moor Gate	16	0.394	0.251

Mudstone, siltstone and sandstone	Yeollandpark	12	0.401	0.256
Totals		**451**	**0.401**	**-0.100**

Table 26. The high and medium probability zones of the cropmarks/soils and bedrock geology model.

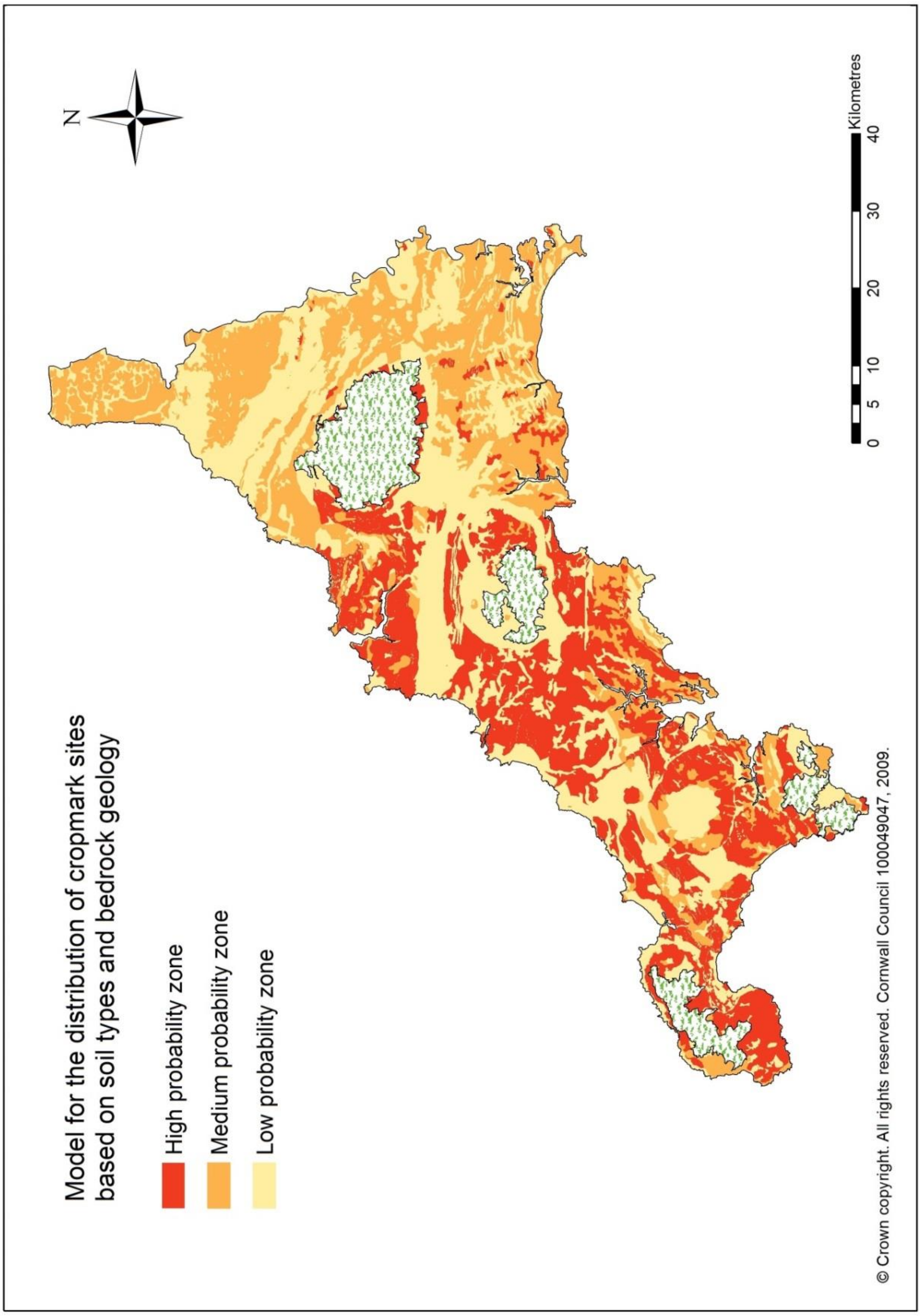

Fig 21. Model for the distribution of cropmark sites based on soil types and bedrock geology.

10.3 The pattern of aerial reconnaissance

10.3.1 Extracting reconnaissance data

Cropmarks of prehistoric and Romano-British sites in Cornwall have been identified and recorded from a range of aerial photographs, including both oblique and vertical images. Vertical photographs are not normally taken for archaeological purposes and those of Cornwall come from a variety of sources, most notably the RAF, Ordnance Survey (OS) and two Census flights commissioned by Cornwall County Council in 1988 and 1995. The pattern of vertical reconnaissance can be regarded as even across the project area (the RAF and Census coverage is county-wide and OS coverage nearly so). Deviations in the reconnaissance pattern therefore result from differential levels of oblique photography resulting from specialist flying carried out by archaeological organisations. A limited amount of reconnaissance was flown by the Cambridge University Committee for Aerial Photography (CUCAP) and by HE (notably in the early 1980s). These, however, amount to only a handful of flights and the bulk of specialist aerial reconnaissance in Cornwall was undertaken by CAU between 1985 and the present. The early flights carried out by CAU were informed by the results of CUCAP and HE reconnaissance and so to a large extent the pattern of CAU flying replicated those earlier flights. Tracing the variations in levels of aerial reconnaissance across Cornwall therefore focused on the patterns of CAU flying. At the outset of this project CAU reconnaissance had produced a total of 10,825 photographs from 87 different flights.

The first stage was to identify those flights during which cropmarks had been photographed. The flight number and date of flight for these site records were then tabulated to produce a list of all flights during which cropmarks were visible. A total of 343 cropmark features were recorded during 46 CAU flights. Obviously conditions were more favourable in some years than others and from flight to flight. For instance, 1989 was an outstanding year for cropmark prospecting in Cornwall, but 1995 and 2004 also produced above average results. Unsurprisingly July is the most productive month; 21 of the successful flights were carried out in July. Overall, apart from a single (anomalous?) flight in November 1990, the date range of the flights falls between 7th April and 11th September.

10.3.2 Plotting the flight paths

The second stage in defining the reconnaissance pattern involved plotting the flight paths of the flights in which cropmark features had been recorded. Although flight plans for all CAU flights exist, their format in the case of the earlier flights (pen-drawn lines on OS base maps reduced to A4 size) precluded the creation of accurate digital versions. Instead the technique used was to plot all photographs taken during the relevant flights as point data (whether the photos were of cropmarks or not) and from the resulting plots to reconstruct the approximate route of each flight.

The map shown in Fig 22 illustrates two weaknesses of the technique used for mapping the flight paths. Firstly, whilst the route of Flight 24 can be fairly confidently reconstructed from the pattern of photography, Flight 65 is focused on two separate areas. It is unclear whether these two areas were deliberately targeted and the land in between was simply flown over, or whether the land in between was subjected to reconnaissance but no sites were observed. A third possibility is that the flight moved from one area to the other by flying over the sea. As a result we do not know whether the land in between was overflown.

The second weakness lies in attempting to make reliable estimates for the visible area covered by each flight. Each point represents a single site in the landscape and the field of vision from the aeroplane might reasonably be estimated as a 1km radius from each site. However, there is no way of knowing whether the flight proceeded directly from site to site or by a more circuitous route. This means that in joining up the points to create a flight path it is difficult to gauge the field of vision for the whole flight. For instance, in the Camel Estuary area (Flight 65, Fig 22), we do not know whether the flight proceeded from one site to another or whether the whole area was circled again and again. In general the rule of thumb adopted was that if the photo points follow a recognisable string the flight path was plotted as a fairly well-defined linear polygon (Flight 24), but if there is a cluster of photo points it was assumed that a wide area has been overflown (Flight 65). In following this policy it is possible that the area covered by CAU reconnaissance has been somewhat overstated.

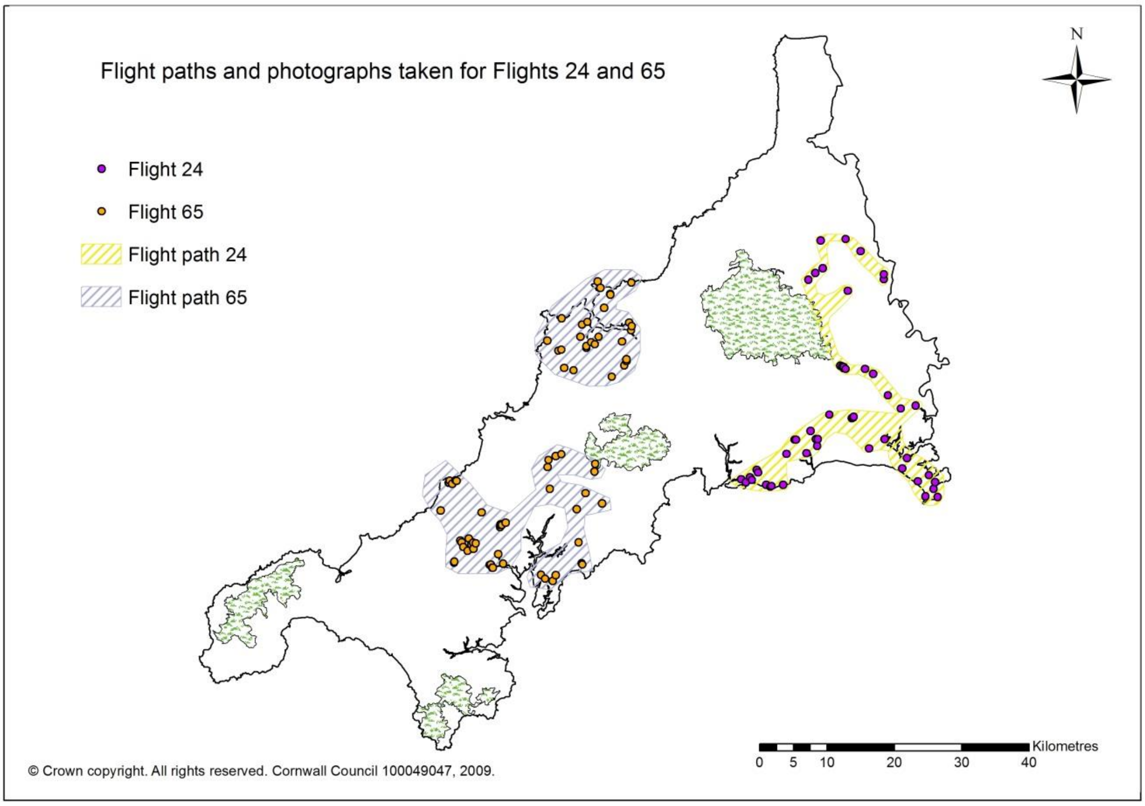

Fig 22. Example of flight path mapping. Flights 24 and 65, showing the location of photographs taken and the approximate flight paths.

Having defined an approximate route for each of the 46 flights the resulting flight paths were then intersected with one another in GIS and new polygons created for the zones of intersection. The polygons were categorised by the number of flight paths overlapping at any one location. The overlap count ranged from one (with only a single flight) to 11 (the polygon had been overflown 11 times). In addition parts of the project area have never been flown during the prime cropmark periods. To produce a model based on the differential intensity of reconnaissance flights the overlap count was simplified into three categories representing well-flown, medium-flown and rarely-flown parts of the project area. The categorisation was defined by considering not just the overlap count but also the proportion of the project area taken up by each overlap count.

It was very clear from this that the areas which had been flown many times were much smaller than those where only a few flights had taken place. In view of this the categorisation was defined as follows.

Category	Overlap count
Well flown	4-11
Medium	2 & 3
Rarely flown	0 & 1

The resulting map based on reconnaissance history is shown in Fig 23. This map very clearly shows those locations where cropmarks are most likely to have been recorded – parts of the north coast (most notably the area around the Camel estuary), an east-west band in central Cornwall, parts of the Lizard peninsula and the Roseland peninsula. On a broader level, parts of east Cornwall have been rarely flown during the cropmark season.

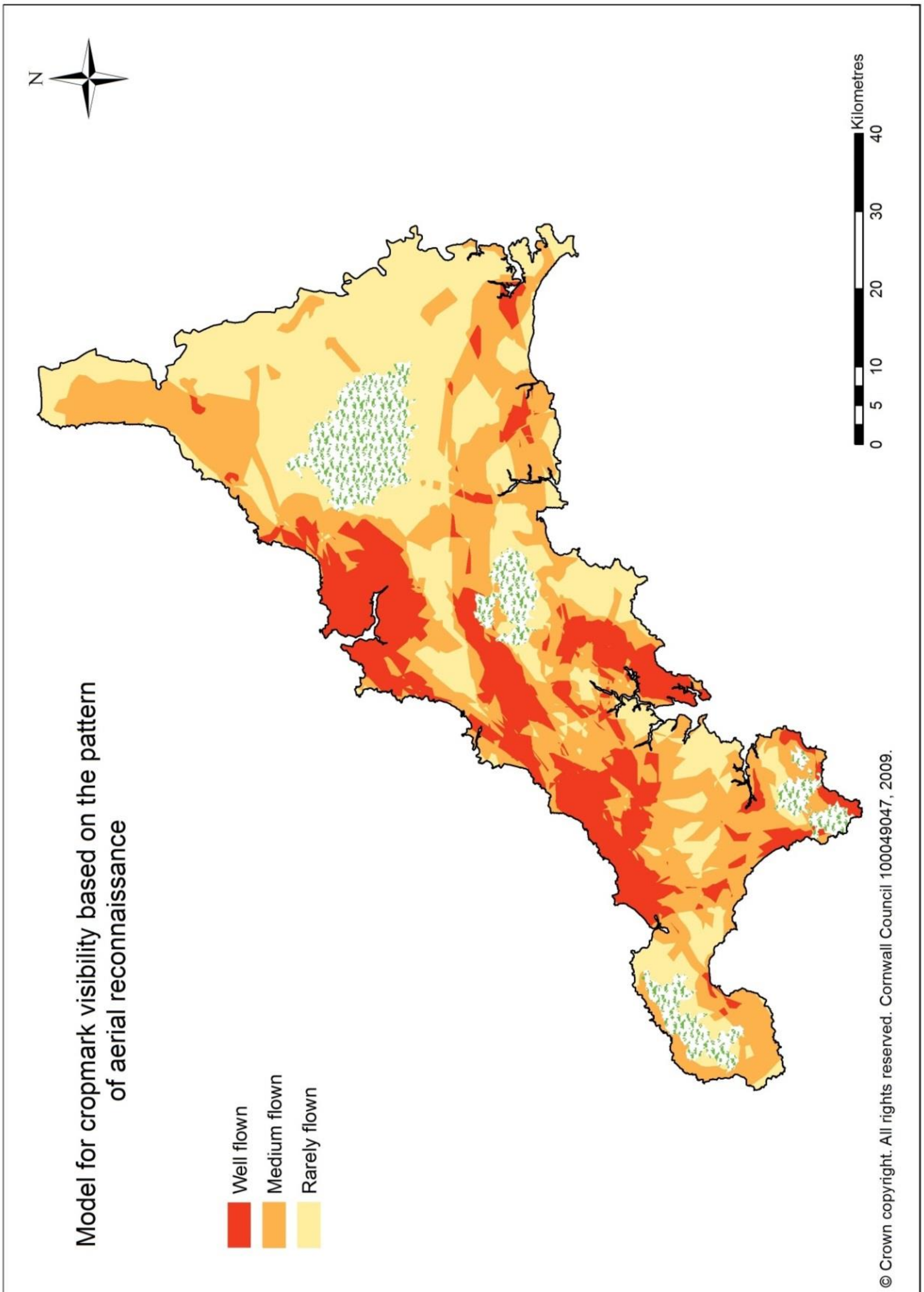

Fig 23. Cropmark visibility model based on aerial reconnaissance.

10.4 The cropmark visibility map

The soils and bedrock geology model shows those areas of lowland Cornwall where cropmarks are most likely to form; the aerial reconnaissance model shows those areas where cropmarks are most likely to have been seen. In order to create a definitive cropmark visibility map, the two were combined.

To do this the zones of high probability in the geology/soils and aerial reconnaissance models were coded as H, the medium probability zones as M and the low probability zones as L. An additional code of N was included for those areas never flown during the cropmark season. To produce a definitive visibility model, both the geology/soils and the aerial reconnaissance models were then combined. The combinations of codes were used to define the zones of high, medium and low probability in the resulting model. Details of this model are shown in Table 27 below. The first letter of the code combinations is derived from the geology/soils model and the second from the aerial reconnaissance model (e.g., the combination HL represents a combination of the high probability zone from the geology/soils model and the low probability zone from the reconnaissance model).

Visibility model. High probability zone					
Weighting	**Cropmarks**	**PA**	**PS**	**Kj**	**Kvamme's gain**
HH	547	0.105	0.311	0.206	0.662
MH	107	0.032	0.061	0.235	0.632
HL	121	0.052	0.069	0.252	0.572
HM	253	0.128	0.144	0.268	0.459
MM	175	0.101	0.099	0.266	0.389
Totals	**1203**	**0.418**	**0.684**	**0.266**	**0.389**
Visibility model. Medium probability zone					
LH	97	0.072	0.055	0.249	0.337
LM	160	0.155	0.091	0.185	0.223
MN	88	0.075	0.050	0.160	0.182
Totals	**345**	**0.302**	**0.196**	**0.160**	**-0.541**
Visibility model. Low probability zone					
ML	80	0.074	0.046	0.132	0.143
HN	25	0.023	0.014	0.123	0.131
LL	60	0.090	0.034	0.067	0.068
LN	46	0.091	0.026	0.002	0.002
Totals	**211**	**0.2783**	**0.120**	**0.002**	**-1.335**

Table 27. Results of the final visibility model.

Probability	**PA**	**PS**	**Kvamme's gain**	**PS/PA**
High	0.418	0.684	0.389	1.64
Medium	0.302	0.196	-0.541	0.65
Low	0.280	0.120	-1.335	0.43

The model performs well, with 68% of the sites captured in a high probability zone covering 42% of the project area; with 19% captured in a medium probability zone covering 30% of the area and a low probability zone covering a similar sized area but containing only 12% of the cropmark sites. The Kvamme’s gain of 0.389 is better than some of the other models produced during this project.

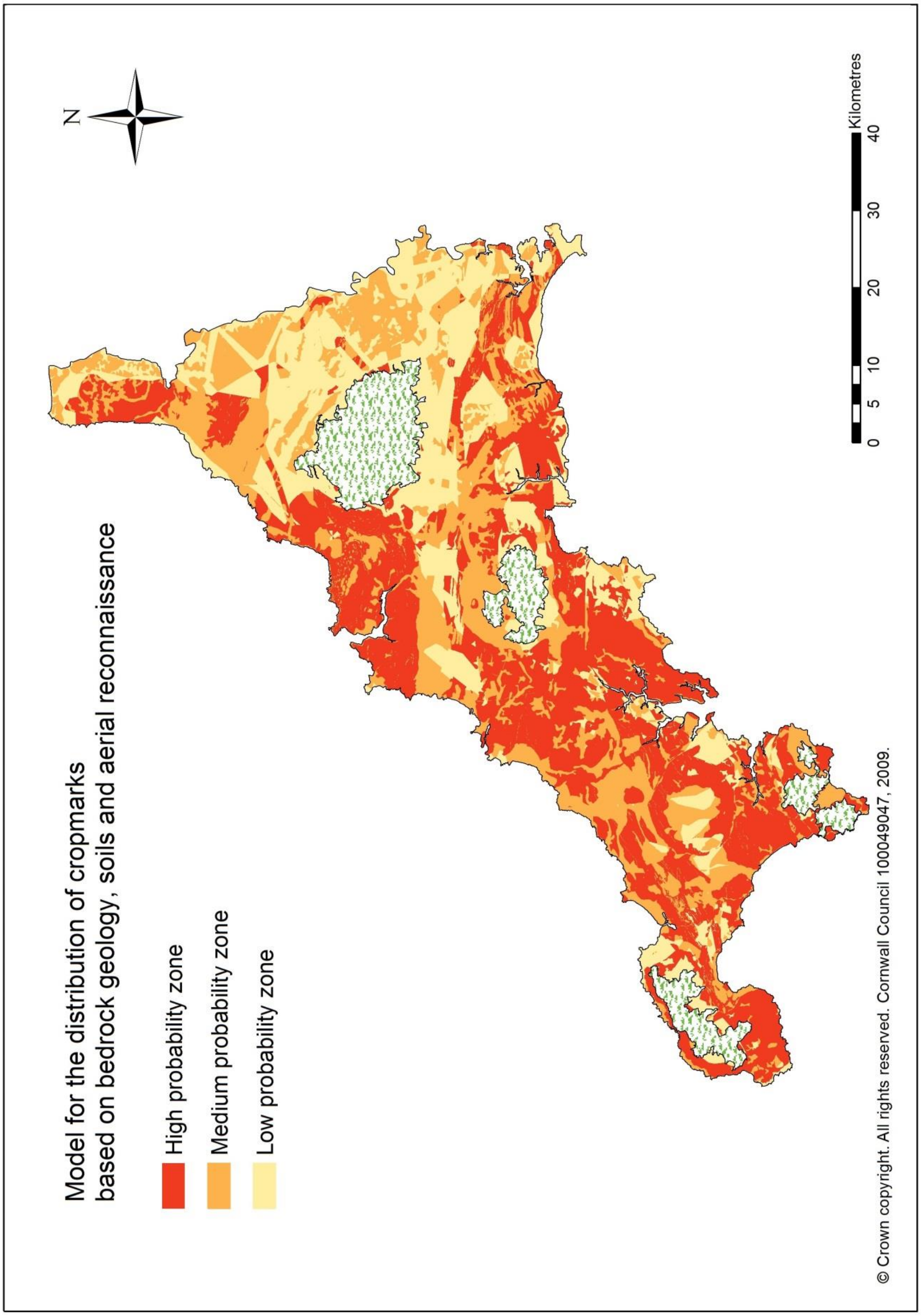

Fig 24. Model for the visibility of cropmarks based on bedrock geology, soils and aerial reconnaissance.

The cropmark visibility map produced by this model (Fig 24) underlines the trend for east Cornwall generally to be characterised as an area of low probability. However, by joining the soils/geology and reconnaissance models a more nuanced version of this broad trend has been achieved. For instance, in the soils/geology model (Fig 21) and in the reconnaissance model (Fig 23) the north eastern tip of the county, around Stratton and Bude, is classed as an area of either medium or low probability. In the cropmark visibility model a portion of this area is placed within the zone of high probability. In the same way, an extensive area close to the southeast coast is classed as a high probability zone in this model whereas in the other models much of the southeast coast is ranked in the low or medium probability zones.

10.4.1 Testing the model

The cropmark visibility model was tested using Events Record data in the same way as the high level HLC models had been tested. However, in this case only the Events falling into categories 3, 4 or 5 were used for testing, because these categories include structural features which might be expected to be visible as cropmarks. The test sample was further reduced by excluding sites which were recorded in the SMR. In total the test sample comprised 230 Events sites represented by 629 polygons, covering an area of 12.25 sq km.

The number of cropmarks per square kilometre (S/A) in the high visibility zone of the model was 0.9, in the medium visibility zone 0.36, and in the low visibility zone 0.25. For the model as a whole there was an average of 0.55 cropmarks per square kilometre. Therefore the notional number of sites and the predicted PS values for the test sample were calculated as follows.

Zone	Area sq km	S/A	Notional sites	Predicted PS
High visibility	21.614	0.90	19.45	0.65
Medium visibility	22.832	0.36	8.22	0.27
Low visibility	9.916	0.24	2.38	0.08
Totals	**54.362**	**0.55**	**29.90**	**1.00**

Table 28. Testing the visibility model: predicted proportion of sites for each visibility zone in the Events Record survey area.

The results of the test were quite different.

Zone	Area sq km	SA	NS	Predicted PS	PS	Predicted Sites	Sites
High visibility	21.614	0.90	19.45	0.65	0.45	150	103
Medium visibility	22.832	0.36	8.22	0.27	0.39	62	90
Low visibility	9.916	0.24	2.38	0.08	0.16	18	37
Totals	**54.362**	**0.55**	**29.90**			**230**	**230**

Table 29. Results of Events Record testing of the visibility model: test based on numbers of sites. NS = notional number of sites predicted.

Zone	Area sq km	Predicted PS	PS	Predicted site area	Site area
High visibility	21.614	0.65	0.39	7.97	4.75
Medium visibility	22.832	0.27	0.44	3.32	5.43
Low visibility	9.916	0.08	0.17	0.96	2.07
Totals	**54.362**			**12.25**	**12.25**

Table 30. Results of Events Record testing of the visibility model: test based on area of events polygons.

The most striking result of testing with Events Record data is the degree to which the cropmarks dataset failed to indicate the likely extent of below-ground archaeology. Whilst the cropmark visibility model suggests that we might expect 30 sites to be recorded in the area surveyed by the Events, the actual figure is almost eight times this. The distribution of the sites, whilst not even, reflects a good spread of sites across the whole project area (Fig 25).

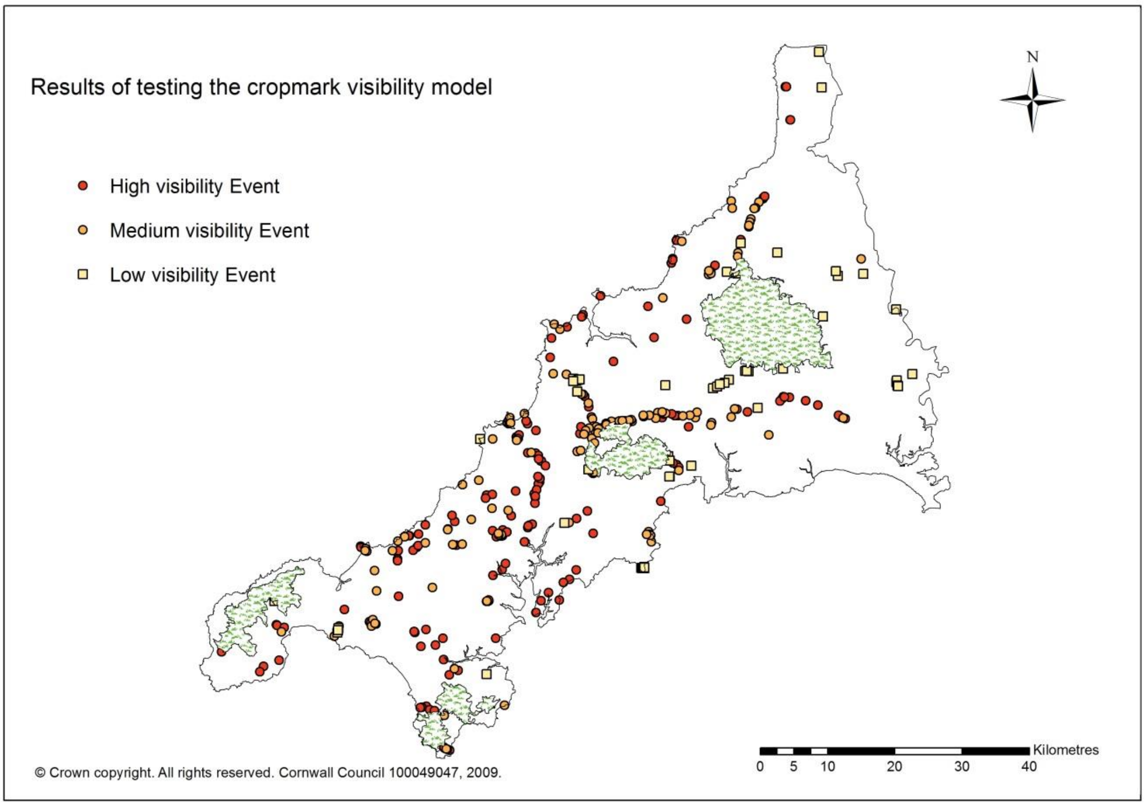

Fig 25. The location of Events record polygons within the visibility zones of the cropmark visibility model.

Fig 25 shows the distribution of the events used in the test as a series of points colour-coded to indicate in which visibility zone they are captured. It is clear from these results that, whether the test is based on site numbers or site area, the cropmark visibility model is rejected by the test sample. Both the medium and low visibility zones perform better than expected, with the low visibility zone in particular capturing more than twice as many sites as predicted and whose polygons cover more than twice the predicted area. The performance of the high visibility zone is especially poor when the test is based on polygon area – with a PS value of only 0.39, as opposed to the predicted 0.65. Furthermore 44% of the area containing below-ground archaeology is captured in the medium visibility zone – a greater area than is captured in the high visibility zone.

The rejection of the model is an important result. Had the model been strongly validated then it could be argued that it is a reliable indicator of the extent of the area in which below-ground archaeology is most likely to be found. Because the test sample represents previously unrecorded archaeology and the model was rejected it can be concluded that the model only shows those areas in which cropmarks are most likely to be visible. In other words, it is exactly as described – a cropmark visibility model, which shows ‘absence of evidence’ rather than ‘evidence of absence’. One possible implication is that the distribution of, for instance, enclosures (more than half of which are recorded as cropmarks) may be biased towards the high visibility zone of this model.

10.5 Other factors influencing the distribution of enclosures

The fact that the cropmark visibility model was rejected when tested with Events Record data raises the question of to what extent is the distribution pattern of enclosures simply reflecting varying degrees of cropmark visibility across the project area. How many undiscovered enclosures are there in parts of the county where cropmarks do not readily form?

To explore this question further, a model was made based on the correlation of the distribution of enclosures with bedrock geology and soils. This model was then amalgamated with the high level HLC model for enclosures. Models were also made separately based on the correlation of enclosures with bedrock geology and with soil types, and the results of these were detailed in Lowland Cornwall Volume 2 (pages 49-58).

10.5.1 The enclosures, bedrock geology and soils model

The enclosures dataset was joined with the combined soils and bedrock data. In total this layer consisted of 558 separate combinations of intersected geology and soil types. A three zone model was then produced using the Kj parameter to measure the importance of each combination and to define the cut off points between the three zones. The high probability zone comprised 14 different combinations of soils and bedrock types, the medium zone contained 20 different combinations and the low probability zone contained the remaining 524 combinations. The result is set out in table 34 and the overall performance of the model is outlined in Table 31.

Probability zone	PA	PS	Kvamme's gain	PS/PA
High	0.35	0.57	0.386	1.63
Medium	0.31	0.22	-0.380	0.72
Low	0.34	0.21	-0.643	0.61

Table 31. Performance of the enclosures, bedrock geology and soils model.

The model is reasonably precise, with the high probability zone covering only 35% of the project area. However, it lacks accuracy in that only 57% of the sites are captured in this zone and that the zones of medium and low probability are very similar in size and contain very similar proportions of sites – to all intents and purposes they are interchangeable. The map based on this model is shown in Fig 26.

This model was then tested using Events Record data. Tests were carried out using all 76 enclosures in the Events dataset and only the 33 previously unrecorded enclosures. In both tests a close fit was achieved by the test sample. Test results for the 33 unrecorded enclosures are shown below.

Probability zone	Area sq km	SA	NS	Predicted PS	PS	Predicted Sites	Sites
High	17.22	1.00	17	0.51	0.48	17	16
Medium	17.73	0.45	8	0.23	0.33	8	11
Low	19.39	0.45	9	0.26	0.18	8	6
Total	**54.36**		**34**			**33**	**33**

Table 32. Results of Events record testing of the enclosures/soils and bedrock model: test based on numbers of sites.

Probability zone	Area sq km	Predicted PS	PS	Predicted site area	Site area
High	17.22	0.51	0.63	84.96	105.50
Medium	17.73	0.23	0.26	39.36	43.82
Low	19.39	0.26	0.11	43.05	18.06
Totals	**54.36**			**167.38**	**167.38**

Table 33. Results of events record testing of the enclosures/soils and bedrock model: test based on site area.

A close fit was achieved for the high probability zone, but the medium probability zone performs better than predicted at the expense of the low probability zone. When the test is based on site area the high probability zone performs much better than predicted at the expense of the low probability zone, whilst the medium probability zone performs much as predicted.

Enclosures/Geology and soils. High probability zone					
Bedrock	**Soil**	**Enclosures**	**PA**	**PS**	**Kj**
Granite	Moretonhampstead	240	0.064	0.123	0.085
Sandstone and [subequal/subordinate] argillaceous rocks, interbedded	Denbigh 2	143	0.036	0.073	0.137
Mudstone and sandstone	Denbigh 2	135	0.042	0.069	0.180
Slate and siltstone	Denbigh 2	122	0.049	0.062	0.210
Slate and sandstone, interbedded	Denbigh 2	85	0.028	0.043	0.237
Hornfelsed slate and Hornfelsed siltstone	Denbigh 2	68	0.026	0.035	0.255
Slate and siltstone	Powys	56	0.015	0.029	0.274
Granite	Moor Gate	47	0.017	0.024	0.287
Slaty mudstone with sedimentary rock, metamorphic rock and igneous rock clasts	Denbigh 2	38	0.005	0.019	0.305
Mudstone	Powys	36	0.007	0.018	0.319
Mudstone, siltstone and sandstone	Powys	35	0.007	0.018	0.333
Hornblende schist	Trusham	32	0.006	0.016	0.346
Slate, siltstone and sandstone	Denbigh 2	42	0.028	0.021	0.348
Sandstone and [subequal/subordinate] argillaceous rocks, interbedded	Denbigh 1	34	0.018	0.017	0.353
Totals		**1,113**	**0.349**	**0.568**	**0.353**

Enclosures/Geology and soils. Medium probability zone					
Bedrock	**Soil**	**Enclosures**	**PA**	**PS**	**Kj**
Slate and siltstone	Denbigh 1	50	0.043	0.026	0.346
Slate, siltstone and sandstone	Denbigh 1	57	0.055	0.029	0.331
Hornfelsed slate and Hornfelsed siltstone	Manod	27	0.013	0.014	0.335
Slate	Denbigh 1	32	0.027	0.016	0.329
Slate and siltstone	Trusham	23	0.009	0.012	0.335
Sandstone	Neath	28	0.024	0.014	0.328
Sandstone and [subequal/subordinate] argillaceous rocks, interbedded	Powys	22	0.014	0.011	0.328
Slate and siltstone	Manod	26	0.028	0.013	0.316
Mudstone and sandstone	Sportsmans	16	0.004	0.008	0.323

Enclosures/Geology and soils. Medium probability zone					
Bedrock	**Soil**	**Enclosures**	**PA**	**PS**	**Kj**
Aplitic microgranite	Moretonhampstead	15	0.002	0.008	0.330
Mudstone and siltstone	Denbigh 1	19	0.018	0.010	0.323
Peridotite and Serpentinite	Croft Pascoe	14	0.004	0.007	0.329
Hornfelsed slate and Hornfelsed sandstone	Manod	15	0.009	0.008	0.329
Slate	Denbigh 2	17	0.019	0.009	0.320
Hornfelsed slate and Hornfelsed sandstone	Denbigh 2	13	0.007	0.007	0.321
Microgranite	Moor Gate	13	0.008	0.007	0.321
Sandstone, siltstone and mudstone	Denbigh 2	14	0.011	0.007	0.317
Metamudstone and metasandstone	Denbigh 2	12	0.005	0.006	0.320
Peridotite and Serpentinite	Trusham	11	0.002	0.006	0.325
Slate and sandstone, interbedded	Powys	11	0.005	0.006	0.327
Totals		**435**	**0.306**	**0.222**	**0.327**

Table 34. Model for the distribution of enclosures correlated with bedrock geology and soils: high and medium probability zones.

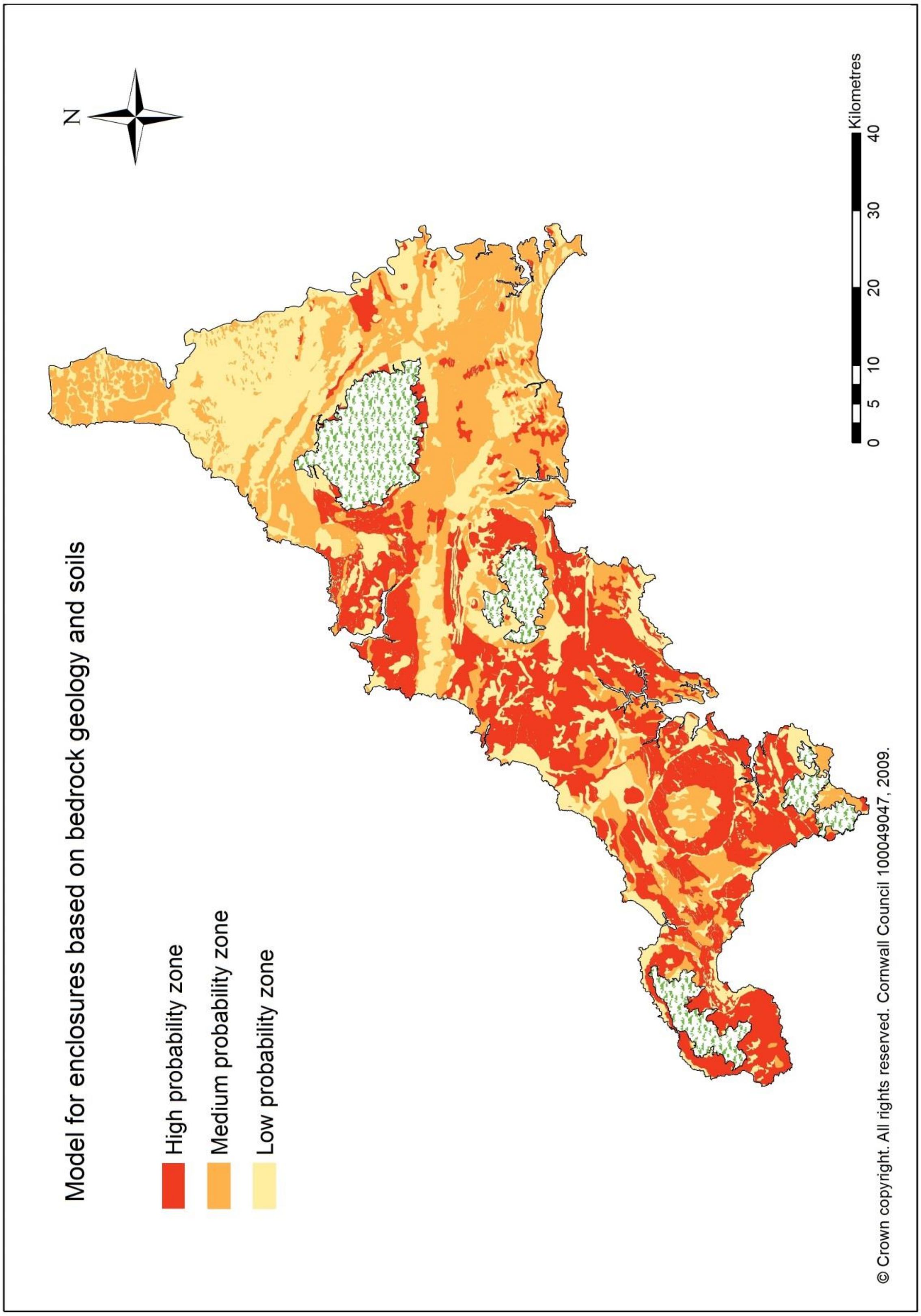

Fig 26. Map showing the enclosures and soils/bedrock geology model.

The most significant difference between the performance of the enclosures model and the cropmark visibility model is that when tested with Events record data the test sample provided a close or reasonably close fit to the enclosures model. This suggests that the high number of enclosures found on certain soil and rock types reflects a deliberate preference for those locations, rather than simply being the result of factors influencing cropmark formation and visibility. Enclosures are recorded from these areas because the soils are the most fertile or easily cultivated and produce the best grassland for grazing, not because they are most conducive to cropmark formation.

This suggestion is supported by analysis of the form of survival of the enclosures.

Zone	Cropmark	Extant	Documentary	Site of	Geophysics	Total
High	60%	52%	55%	45%	75%	**57%**
Medium	21%	23%	24%	31%	25%	**22%**
Low	19%	25%	21%	24%	0%	**21%**

Table 35. Analysis of form of survival of sites in each probability zone of the enclosures/bedrock and soils model.

In this table the final column on the right shows the percentage of all enclosures captured in each of the probability zones, so 57% of the enclosures are captured in the high probability zone, 22% in the medium probability zone and 21% in the low zone. The other columns show the percentage of enclosures in each probability zone according to their form as recorded in the SMR. For instance, 60% of cropmark enclosures, 52% of extant enclosures, 55% of enclosures recorded from documentary evidence, 45% of enclosures recorded as 'site of' and 75% of enclosures found by geophysical survey are captured in the high probability zone of the soils model (only four enclosures are recorded in the SMR from geophysical survey so this figure is not significant).

Ignoring the enclosures recorded by geophysical survey, the percentages of captured enclosures according to form (52% - 60%) closely resemble the overall percentage of enclosures captured in the high probability zone, apart from those recorded as 'site of' (45%). The same is true of the medium probability zone of this model, and likewise the low probability zone. In other words, the percentages of extant and documentary enclosures in each of the zones are similar to the percentage of all enclosures captured in each zone. It can be concluded from this analysis that if there is any bias in the model towards cropmark sites then it is minimal.

The possibility that there may be archaeologically significant regional variations in the distribution of enclosures is further suggested by variations in the density of enclosure distribution in areas overlying similar soil types. The best example is Denbigh 1 and Denbigh 2 soils, both of which are described as 'loam over shale' with the underlying geology being 'Palaeozoic slaty mudstone and siltstone'. These are by far the two most extensive soil types in lowland Cornwall, covering 21% and 29% of the landscape respectively. Although there are some slight differences in the underlying geology there are more similarities between the two types. However, virtually three times as many enclosures are recorded from Denbigh 2 soils than from Denbigh 1 (751 compared with 252). In fact, one is twice as likely to encounter an enclosure on Denbigh 2 soils as on Denbigh 1. There is a striking regional distinction in the distribution of the two soils, with Denbigh 2 predominantly occurring in central areas and Denbigh 1 mainly confined to southeast Cornwall (Fig 27).

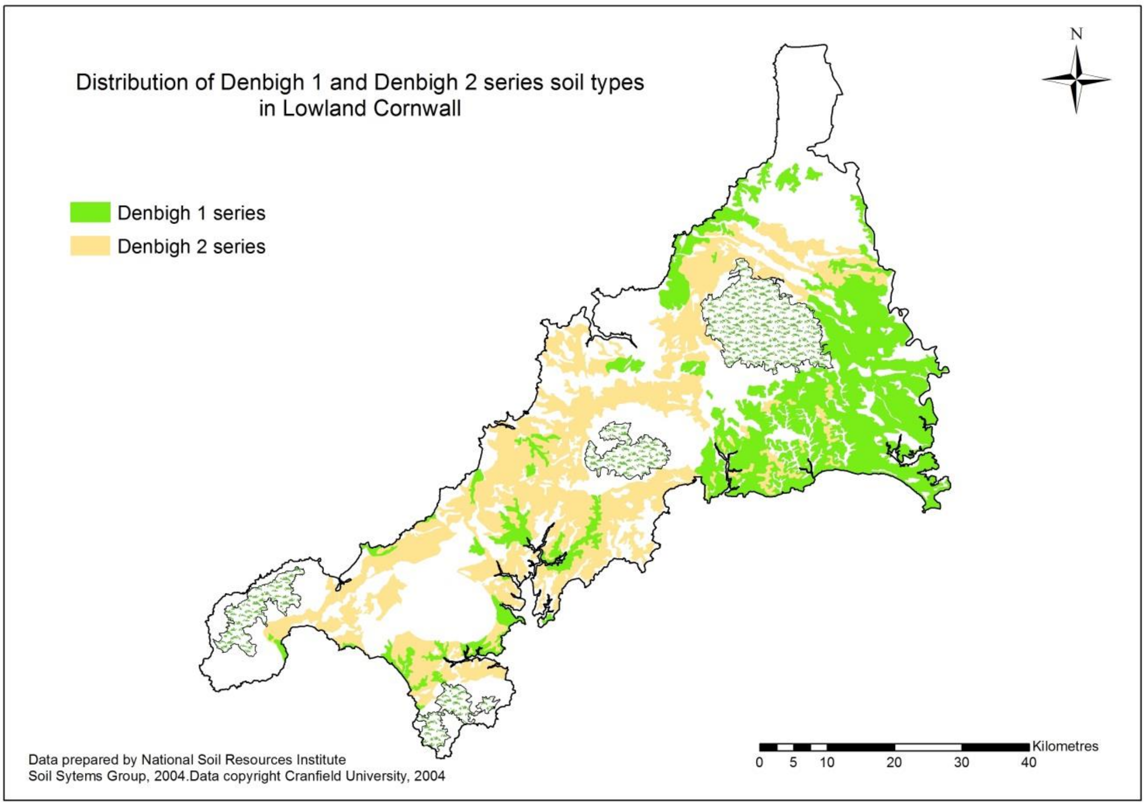

Fig 27. Map showing the distribution of Denbigh 1 and Denbigh 2 soil types in Lowland Cornwall.

The fact that there is such a clear disparity between the densities of enclosure distribution over two virtually identical soil types does hint at a genuine regional variation to the pattern, with fewer enclosures in eastern and south eastern areas of the county.

10.6 The enclosures/soils, bedrock and HLC model

The model correlating the distribution of enclosures with bedrock geology and soil types appears to accurately reflect the known distribution of enclosures in lowland Cornwall, with a clear bias towards western and central areas. This contrasts somewhat with the model based on the distribution of enclosures correlated with HLC Types. The high probability zone of that model included extensive areas in east Cornwall, whilst parts of west Cornwall (notably around Camborne, Redruth and Hayle) were classed as medium or low probability.

One issue with the HLC model is its lack of precision, due to the large area covered by the high probability zone. In an attempt to increase model precision, the HLC Types were combined with the bedrock geology and soils datasets, and the combined datasets were used as variables for modelling the distribution of enclosures. Models were also built using combinations of soil types and HLC Types and also bedrock geology data and HLC Types. The details of these models were presented in Lowland Cornwall Volume 2 (pages 66–79).

If the HLC model was combined with the soils/bedrock model using the spatial union tool in GIS the resulting shapefile would comprise a large number of combinations and a very large number of polygons; the ensuing model building would be extremely time-consuming. For this reason a simplified method was used to create this particular model. The three probability zones of both models were coded as H for the high, M for the medium and L for the low probability zones. A spatial union of the two models was carried out based on the probability zone code. In the resulting code combinations the code from the geology and soils model precedes that from the HLC model. So, for example, the code combination HL is land that is in the high probability zone of the geology and soils model and in the low probability zone of the HLC model.

The make-up of the model is shown in table 36 below.

Zone	Coding	Sites	PA	PS	Kj
High	HH	916	0.24	0.47	0.324
	MH	336	0.21	0.17	0.344
Total		**1,252**	**0.45**	**0.64**	**0.344**
Medium	LH	299	0.20	0.15	0.328
	HM	142	0.06	0.07	0.3600
Total		**441**	**0.26**	**0.22**	**0.3600**
Low	MM	76	0.05	0.04	0.349
	HL	54	0.05	0.03	0.330
	LM	68	0.07	0.03	0.276
	LL	43	0.07	0.02	0.175
	ML	23	0.04	0.01	0.000
Total		**264**	**0.28**	**0.13**	**0.000**

Table 36. The HLC/bedrock and soils model for enclosures.

The overall performance of the model is summarised below. Although the Kvamme's Gain is a modest 0.289, this is higher than that achieved by the enclosures/HLC model and it is reasonably accurate, with 64% of the sites captured in the high probability zone. The medium probability zone performs well (with PA and PS values being almost equal), although it is quite large, and the low probability zone (13% of sites in 28% of the project area) is both accurate and precise.

Probability zone	PA	PS	Kvamme's gain	PS/PA
High	0.46	0.64	0.289	1.41
Medium	0.26	0.23	-0.161	0.86
Low	0.28	0.13	-1.104	0.48

The relative contribution to the combined model made by each of the original models can be compared by analysing the code combinations within each probability zone. The three highest ranked categories are made up of the high probability zone (code H) from the HLC model (HH, MH and LH). Where the high probability zone from the geology/soils model is combined with the low probability zone from the HLC model the combined category (HL) is only ranked sixth. This trend can be seen throughout the rankings; MH is ranked higher than HM, LM is ranked higher than ML, and so forth. This suggests that the HLC model is a more powerful indicator of probability than the geology/soils model.

The probability map derived from this model offers a compromise between the HLC and bedrock/soils models. On the one hand, the area of high probability covering 66% of the project area in the HLC model is reduced by 20% in extent; on the other the abrupt boundary between east Cornwall (largely medium and low probability) and central/west Cornwall (largely high probability zone) which is such a distinctive feature of the bedrock/soils model is to a large degree softened in this combined model (Fig 28).

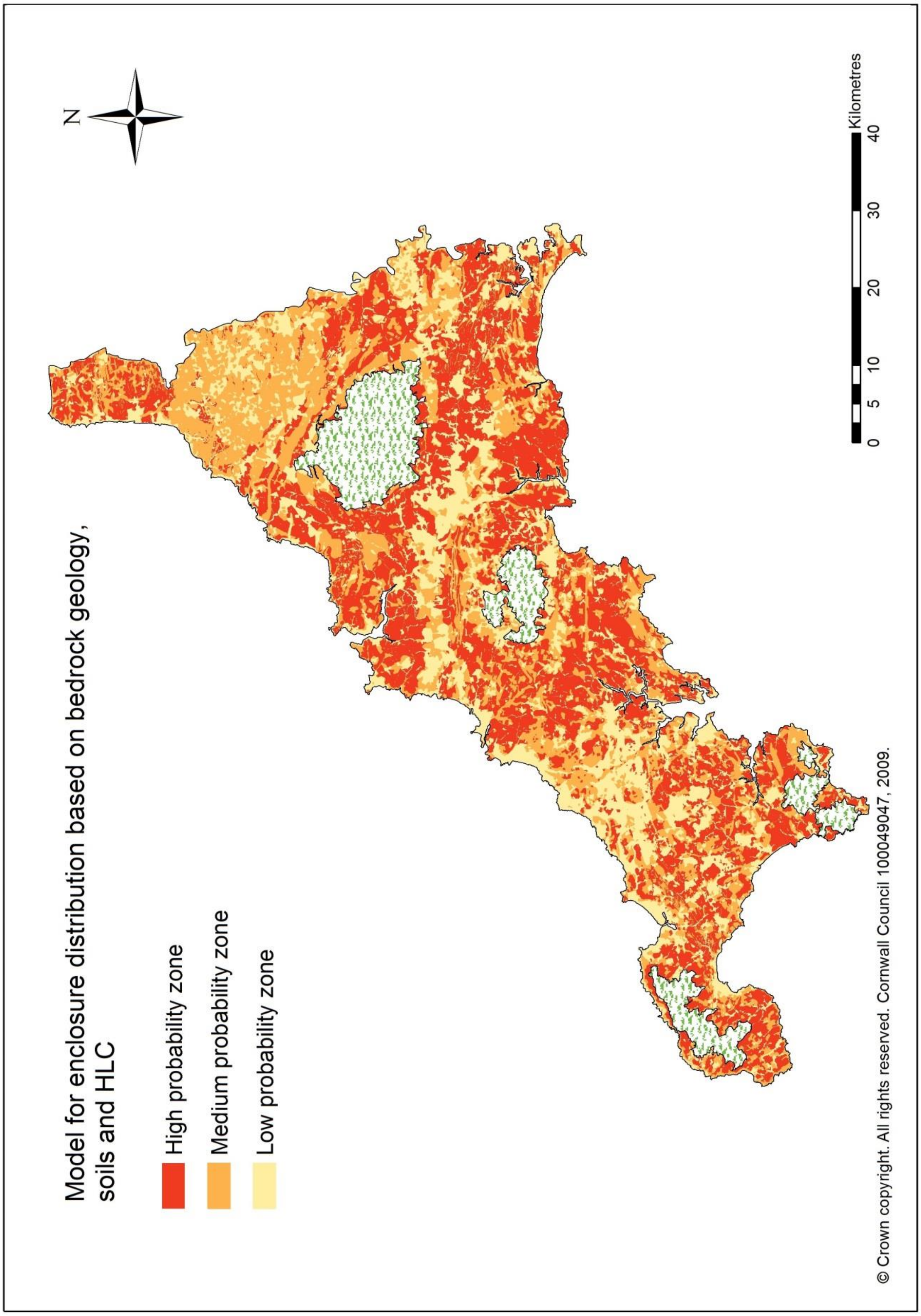

Fig 28. Map showing predictive model for enclosures using bedrock geology, soil types and HLC Types as variables.

10.6.1 Testing the model

The enclosures/bedrock, soils and HLC model was tested using Events Record data in the same way as the other models discussed so far.

Testing with all 76 sites

Zone	Area sq km	SA	NS	Predicted PS	PS	Predicted Sites	Sites
High probability	22.637	0.86	19.47	0.61	0.55	46	42
Medium probability	13.211	0.53	7.00	0.22	0.22	17	17
Low probability	18.468	0.29	5.36	0.17	0.22	13	17
Totals	**54.316**		**31.83**			**76**	**76**

Table 37. Results of Events record testing of the enclosures/bedrock, soils and HLC model: test based on numbers of sites.

In this test the high probability zone does not perform quite as well as predicted because the low probability zone captures more enclosures than expected. The medium probability zone performs exactly as predicted.

When the test is based on site area rather than number of sites the medium probability zone and the low probability zone perform slightly better than predicted at the expense of the high probability zone. Overall, however, the high probability zone performs better than when the test is based on numbers of sites.

Zone	Area sq km	Predicted PS	PS	Predicted site area	Site area
High probability	22.637	0.61	0.58	2.53	2.39
Medium probability	13.211	0.22	0.24	0.91	0.99
Low probability	18.468	0.17	0.18	0.70	0.76
Totals	**54.316**			**4.14**	**4.14**

Table 38. Results of events record testing of the enclosures/bedrock, soils and HLC model: test based on site area.

Testing with the 33 new sites

When the test is carried out using only the previously unrecorded enclosures and based on numbers of sites, the model performs much as predicted, with the high probability zone capturing 58% of the sites. The medium probability zone captures 5% more enclosures than predicted at the expense of the low zone.

Zone	Area sq km	SA	NS	Predicted PS	PS	Predicted Sites	Sites
High probability	22.637	0.89	26	0.61	0.58	20	19
Medium probability	13.211	0.64	5	0.22	0.27	7	9
Low probability	18.468	0.26	4	0.17	0.15	6	5
Totals	**54.316**		36			33	33

Table 39. Results of events record testing of the enclosures/bedrock, soils and HLC model: test based on numbers of new sites.

Zone	Area sq km	Predicted PS	PS	Predicted site area	Site area
High probability	22.637	0.61	0.69	1.03	1.16
Medium probability	13.211	0.22	0.23	0.37	0.40
Low probability	18.468	0.17	0.08	0.29	0.13
Totals	**54.316**			1.69	1.69

Table 40. Results of events record testing of the enclosures/bedrock and HLC model: test based on new site area.

When the test is carried out based on site area the high probability zone performs significantly better than predicted, largely at the expense of the low probability zone.

The apparent discrepancy in the performance of the low probability zone when measured by site area as opposed to numbers of sites (a PS value of 0.08 as opposed to 0.15) is due to the way the area polygons were defined (using present day field boundaries). The mean size of the polygons defining new enclosures in the low probability zone is 1.4ha, compared with 3.2ha for the high probability zone. All in all, however, the model can be said to be verified by the test sample.

10.6.2 Discussion

Unlike the model for cropmarks, the high probability zones of these models were verified when tested using the Events Record data.

The fact that the models were largely verified by testing suggests that the influence of soils and geology on the location of enclosures is archaeologically meaningful and does not simply highlight those below-ground conditions most favourable for cropmark production. This view is corroborated by analysis of the form of survival of enclosures in each of the probability zones of the models. The proportion of extant enclosures captured in each probability zone of each model is actually very similar to the overall proportion of enclosures captured in each probability zone. In other words the high probability zones of these models would remain the high probability zones if the cropmark enclosures were removed from the equation, and any bias in the models towards cropmark sites appears to be slight.

Another significant factor is the varying density of enclosure distribution over soil or rock types that are essentially very similar, but which occur in different parts of the county. The clearest example of this is a comparison of the numbers of enclosures located on Denbigh 1 and Denbigh 2 soils; these two soil types are closely related and overlie similar rock types but where they are found in central and western areas far greater numbers of enclosures are recorded than where they occur in east Cornwall. The suggestion is that, for whatever reason, fewer enclosures were established in eastern parts of the county than were in the western and central areas.

11 HLC deepening

11.1 Introduction

Historic Landscape Characterisation was developed to give a landscape-scale overview of the history of the present landscape and the general processes that have helped to form it. It is part of a larger European-wide movement to create a planning environment that understands change at a landscape level rather than one based on site specific designations. It aspires to be simple and generalised in application and appreciation, though it has the flexibility in its method to contain more detailed information.

Every part of the project area is mapped without bias to certain localities. Across an entire area, and usually at a regional scale, broad patterns of similar landscape are grouped into parcels of similar 'character' or 'Type', defined by recurring historic attribute values (features) and shared 'time-depth'. Common, widely available sources (historic maps and aerial photographs for example) and further supporting evidence (county Historic Environment Records - HER) are normally used to inform the judgment process.

A guiding principle behind HLC is to focus on the historic components of the present landscape. However, HLC can also be used to produce 'snapshots' of activity in past periods or 'time-slices'. A primary objective of the HLC methodology is for the assessor to identify the dominant types of character or activity. Historic Landscape Characterisation is not focussed on plotting the exact extent of land use, especially at its higher (simpler) levels of characterisation (e.g. Broad Type), although it has some flexibility in its method to record more complex information (Clark *et al* 2004, 9).

Cornwall's was the first countywide HLC, carried out in 1994 (Cornwall County Council *et al* 1994; Herring 1998). The method used was 'prescriptive' or 'classification-led', whereby areas of land were assigned to a pre-defined character Type on the basis of attribute values (e.g. the degree of sinuosity of field boundaries, the size and shape of fields, and the regularity of field patterns) shown on modern map data, with other supporting evidence used to confirm definitions (settlement place-names for example). In the 1994 characterisation Cornwall's HER was not used as supporting evidence.

Since 1994 other countywide mapping has been undertaken but with differences in methodology. A 'descriptive' or 'attribute-led' approach was used in the Lancashire, Herefordshire and Somerset HLC projects (Aldred and Fairclough 2003; Clark *et al* 2004). In this method it is only after the mapping stage is completed across the entire project area that character Types are identified by data grouped from the statistical analysis of attribute values.

There are both advantages and disadvantages to the prescriptive and descriptive methods, and in 2002 the *HLC Method Review* concluded that a combined prescriptive/descriptive method would produce the best results for future practice The review demonstrated that the descriptive attributes could be used to support the prescriptive classifications in terms of differences in the attribute values, and that some flexibility in the groups of values could be accepted to allow for the complexity of the landscape, the project aims and for further reassessment (see Aldred and Fairclough 2003 for full discussion).

A development in the production and use of HLC in Cornwall since 1994 has been the introduction of GIS software. This has enabled the Lowland Cornwall HLC mapping to be informed by a greater range of sources, and to be characterised with a greater range of supporting descriptive attributes, allowing it to be queried in a greater range of ways.

By combining HLC Types with geology and soils data, it was possible to produce rather more precise models for enclosure distribution than by using HLC Types alone as variables (section 10.5). Another way in which the project aimed to increase the precision of the HLC models was by carrying out a deepening of the existing HLC to a finer granularity, in the expectation that some types of Farmland Medieval would be more site-rich than others, thereby allowing the high probability zone to be more precisely defined.

Available resources did not allow HLC deepening for the entire Lowland Cornwall project area. Instead it was carried out in four discrete study areas covering 384 square kilometres in total (Fig 29). A number of factors were taken into consideration when selecting the study areas:

1. The definition of the study areas should be based on ecclesiastical parishes rather than the OS national grid.
2. The study areas should be geographically remote from each other and have contrasting landscape characters.
3. The four areas should have contrasting levels of high or low visibility, as identified in the cropmark visibility model.
4. They should have differing levels of NMP mapped sites (i.e. areas of high site density and areas where little was mapped).
5. There should be consideration of the 1994 HLC. For instance, an area of Anciently Enclosed Land (AEL) which is close to an extensive area of Upland Rough Ground (URG), and an area of AEL which is distant from any extensive area of URG, to more fully explore the relationship between AEL and URG.
6. There should be consideration of any anomalies, inconsistencies or notable patterns arising from the high level models. A good candidate would be parts of the West Penwith lowlands to enable the deepening of the HLC Type Farmland Prehistoric.
7. Areas of the HLC Type Farmland Prehistoric beyond its limit as defined in the 1994 HLC might be identified by selecting parts of the Lizard Peninsula or St Hilary parish as a study area.
8. Some, or all, of the study areas should contain as many different HLC Types as possible to enable a comprehensive comparison of refined HLC and 1994 HLC, and also to compare the 2011 time-slice with previous time-slices in as wide a range of Types as possible.
9. Consideration should be given to the geographical cover provided by data and information sources, in particular digital Tithe mapping.

Probus (135.5 sq km)

The Probus study area comprises the ecclesiastical parishes of Probus, St Enoder, St Newlyn East, St Erme and Ladock. The study area contains 15 of the 20 1994 HLC Types. It contains large tracts of rich land; much of it falls within the high visibility zone of the cropmarks visibility model and many below-ground prehistoric features were mapped here during Cornwall's NMP. It borders the Upland Rough Ground of the Hensbarrow granite and parts of it could be described as quintessentially 'lowland Cornwall'.

Penwith (93.8 sq km)

The Penwith study area comprises the ecclesiastical parishes of Paul, Marazion, St Hilary and Perranuthnoe, most of the parishes of St Buryan and Ludgvan, and parts of Lelant, Gulval and Madron (the remainder of these parishes are located in upland areas and are therefore outside the project area). The study area contains 17 of the 20 1994 HLC Types. Large parts of this study area fall within the high visibility zone of the cropmarks visibility model and a number of below-ground features were recorded here during Cornwall's NMP. It borders the West Penwith uplands area of Upland Rough Ground.

Pelynt (89.2 sq km)

The Pelynt study area comprises the ecclesiastical parishes of Boconnoc, Fowey, Golant, Lanreath, Lanteglos by Fowey, Pelynt and St Veep. The study area contains 15 of the

20 1994 HLC Types. Most of the area falls within the high visibility zone of the cropmarks visibility model, but there are significant belts of land falling in the medium and low visibility zones. Few below-ground features were recorded here during Cornwall's NMP. Despite containing some elevated areas, such as Bury Down, the Pelynt study area lies a considerable distance from any extensive area of rough ground (the nearest is Bodmin Moor).

Poundstock (65.6 sq km)

The Poundstock study area comprises the ecclesiastical parishes of Jacobstow, Marhamchurch, Poundstock and Whitstone. This study area encompasses a less contiguous block of landscape than the other three and is the smallest of the four. It contains only 14 of the 1994 HLC Types. Northern and southern parts of the study area fall within the high visibility zone of the cropmarks visibility model, the central area is in the medium visibility zone and western and eastern parts are in the low visibility zone. Very few below-ground features were recorded here during Cornwall's NMP. It lies some 8.5 km from the northern part of Bodmin Moor, which is the nearest extensive area of Upland Rough Ground.

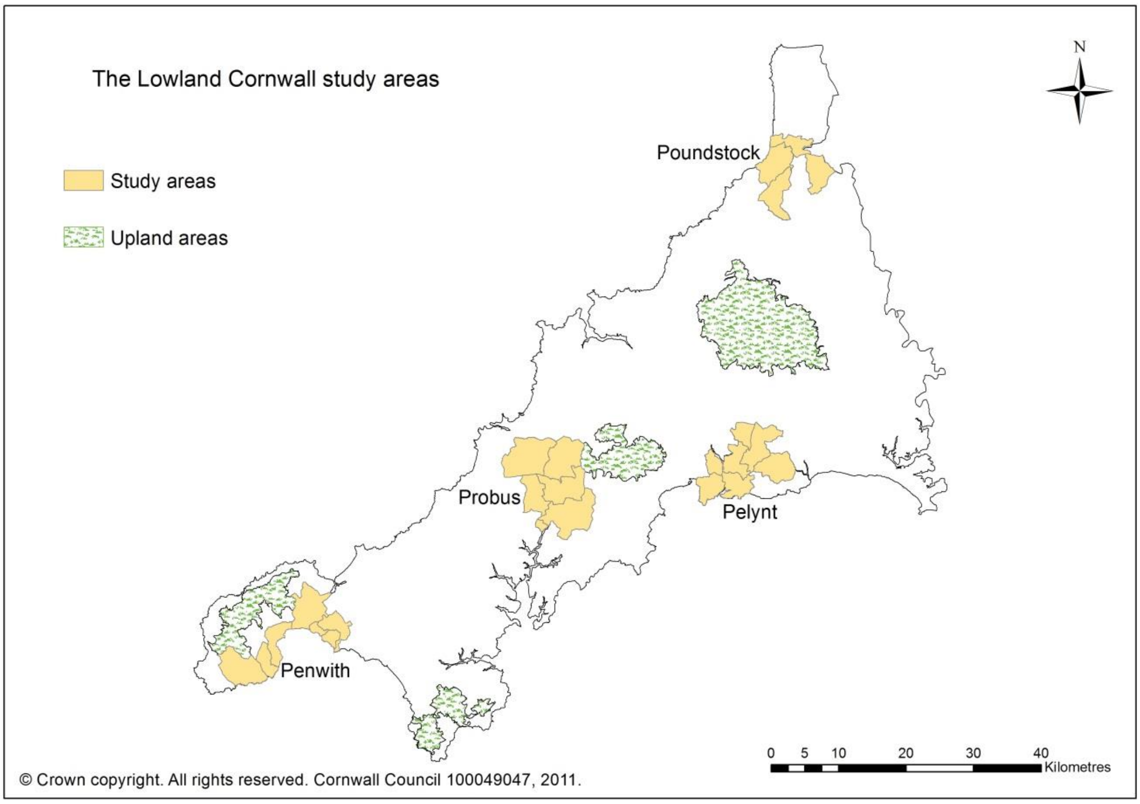

Fig 29. The four Lowland Cornwall study areas.

The underlying bedrock geology and soils differ in each of the four study areas and, as can be seen in Fig 29, they are widely dispersed in different parts of the county.

11.2 Lowland Cornwall HLC methodology

The methodology was based on best practice (Aldred and Fairclough 2003); a GIS based project with both prescriptive and descriptive elements, with a background table of HLC fields populated with attribute values for each polygon, a general restriction of 1ha on polygon size, and the production of explanatory or descriptive texts for each Type. The modern 1:10,000 digital map at the scale of 1:5,000 was used to produce the Lowland Cornwall HLC 2011 time-slice, although for accuracy polygons were drawn at 1:2,500 using the latest version of the OS Master Map data.

HLC mapping was carried out on ArcGIS 9.2 software with attributes entered into an accompanying Access database. This was undertaken on a parish by parish, study area by study area basis. With the completion of mapping in each parish, the GIS and Access datasets were joined, and the final dataset exported to GIS.

The following were created as part of the refinement process:

- HLC (including 2011, 1880 and 1840 time-slices with full attributes and where possible and appropriate, two further Late Medieval and Late Prehistoric interpretative time-slices with no attributes)
- Historic Settlement data (place-name and history of settlement development).

At the top of the Lowland Cornwall HLC hierarchy is a 'Broad Type' with increasing levels of complexity beneath it. Broad Type is sub-divided to form a more specific 'HLC Type'; within 'Enclosed Land' this can be further sub-divided to a detailed 'Sub-Type' level, defined by a complex set of attribute values. In other words:

Broad Type: Enclosed Land (simple set of attribute values)

HLC Type: Medieval Enclosed Land (moderately complex set of attribute values)

Sub-Type: Medieval derived from Strip Fields (complex set of attribute values)

The parish of St Newlyn East in the Probus study area was chosen as a pilot to trial the method. The availability of the digital 1880 OS and 1840 Tithe maps enabled the full completion of HLC fields for these two time-slices. This, it was envisaged, would enable a clearer understanding of landscape change in the past 170 years. Where understood, two further 'interpretive time-slices' beyond the 1840 time-slice could also be added corresponding with the 'late medieval' and 'late prehistoric' periods. HLC mapping in the pilot parish confirmed the value of the 1880 and 1840 time-slices as they enabled a complex picture of landscape change to be drawn.

Widespread change to the St Newlyn East landscape, particularly alterations to the field pattern, was recorded across the parish. Alteration was not evenly spread, varying from location to location, time-slice to time-slice, and with change not easily generalised on a parish-wide basis. Amalgamation, sub-division and re-arrangement of fields all occurred with great differences in scale and impact. In the majority of instances alteration was noted in the differences in attribute values for areas between time-slices. Occasionally, however, wholesale change could result in the same/or similar number of fields and dominance of boundaries, for example, eight fields replaced by eight fields.

To record these changes in a simple way, in a prescriptive manner rather than based on attribute values alone, a series of Sub-Types for altered land were created:

- Amalgamated
- Sub-Divided
- Re-arranged

Therefore, if the character of a group of fields classed as Medieval Enclosed Land had been altered by the later addition of sub-dividing boundaries, these fields would be interpreted as 'Medieval Altered field patterns (Sub-Divided)'.

Further context was provided by a separate supporting Historic Settlement dataset. This was mapped separately as a GIS-based layer of point data with attribute values. Its basis was the Historic Environment Service (HES) transcription of the Institute of

Cornish Studies (ICS) Place-name Index (Historic Environment Service undated). The value of the dataset was the ability to better identify potential continuity of land use and change to settlement size and character (and therefore understand changes to the surrounding HLC). As with the revised HLC, time-slices were chosen on the availability of GIS-based maps, which is to say in 2011, 1880 and 1840.

A 1748 time-slice was also added to understand settlements prior to the Industrial Revolution. The source used was Martyn's 1748 Map of Cornwall. This used a set of conventions to distinguish mansion houses (wealthy land-owners' residences), single farms, mills, churches, hamlets, villages and towns. Martyn also mapped enclosed land separately from open or rough ground and the map was useful in helping to validate the location of Early Modern and Modern Enclosed Land in respect of HLC.

The Historic Settlement supporting layer was the first dataset to be completed for the parish. This was useful as it provided a framework of background information which ensured the HLC was undertaken from a more informed understanding of the landscape. This work pattern, with Historic Settlement data mapped prior to the HLC stage, was repeated parish by parish throughout the project.

Following mapping of the pilot parish a 'Landuse' attribute was added to the HLC database. This attribute aimed to assess the potential continuity in settlement and land use history of all the terrestrial polygons in the HLC. The supporting evidence of the Historic Settlement data was crucial in the production of this dataset. Certain Cornish place-name elements, for example *tre-*, have been dated to the fifth to tenth centuries AD, and therefore could be interpreted as likely to be areas of continuous settlement since the end of the Romano-British period. Further Cornish and English place-name evidence was used to identify 'Core', 'Sub-core', 'Fluctuating/Tidal' and 'Marginal' areas of settlement land use. The Landuse attribute had several limiting factors but it was judged to have potential value in the predictive modelling stage of the project (section 13.1).

A full description of the methodology used was contained in Lowland Cornwall Volume 3, section 2 and full details of the Lowland Cornwall HLC and Historic Settlement database was contained in Volume 3, Appendices 1 and 2. Summary descriptions of the HLC Types and Sub-Types are contained in Appendix 2 of this report.

11.3 Probus

The Probus study area is located in mid Cornwall (Fig 29), occupying an area of 135.495 sq km (Fig 30). Its southern edge is near the more sheltered south coast, its northern edge closer to the more windswept north coast. The area is characterised by dendritic stream valleys which lead inland from estuary systems (Gannel and Tresillian Rivers). These are flanked by ridges of higher ground leading to Newlyn Downs, a central east-west ridge of high ground standing at 110m to 145m OD. In the parishes of Ladock and St Enoder, the upper reaches of the steeper-sided valleys open to form more shallow-sided open areas with poorer drainage. Near Fraddon, the northeast corner of the area rises to 220m OD, lying on the edge of the high ground of the Hensbarrow granite.

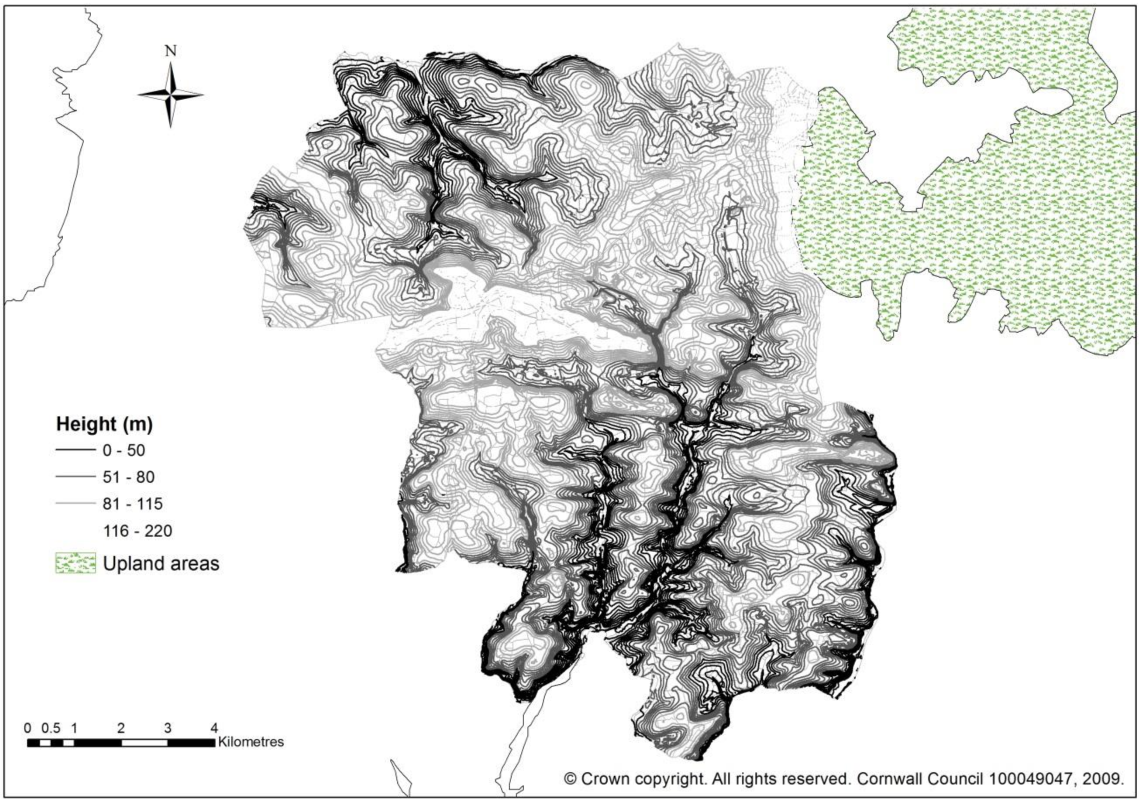

Fig 30. The Probus study area topography.

The river valleys are an important part of the physical and human landscape, forming significant landscape boundaries, and some sections of these natural features have been used to demarcate the boundaries of parishes.

A comparison of the percentage of the study area taken up by each HLC Type in the 1994 and the equivalent deepened 2011 HLC is shown in Table 41.

HLC Type	% Area (1994)	% Area (2011)
Communications	1.10	1.10
Industrial	0.57	0.63
Medieval Enclosed Land	56.91	66.34
Post-Medieval Enclosed Land	24.66	6.32
Modern Enclosed Land (including Early Modern)	3.37	12.33
Mudflats and saltmarsh	0.08	0.01
Parkland	1.17	0.87
Plantation and shelterbelt	1.14	1.27
Recreational	0.26	0.48
Settlement	2.45	2.45
Upland and valley rough ground	3.96	3.96
Woodland	4.24	4.24

Table 41. Probus study area: comparison between 1994 and 2011 HLC.

The biggest difference is that in the refined HLC 18% less of the area is interpreted as Post-Medieval Enclosed Land. Roughly half of this has been re-interpreted as Modern or Early Modern in date and half as Medieval Enclosed Land (Fig 31).

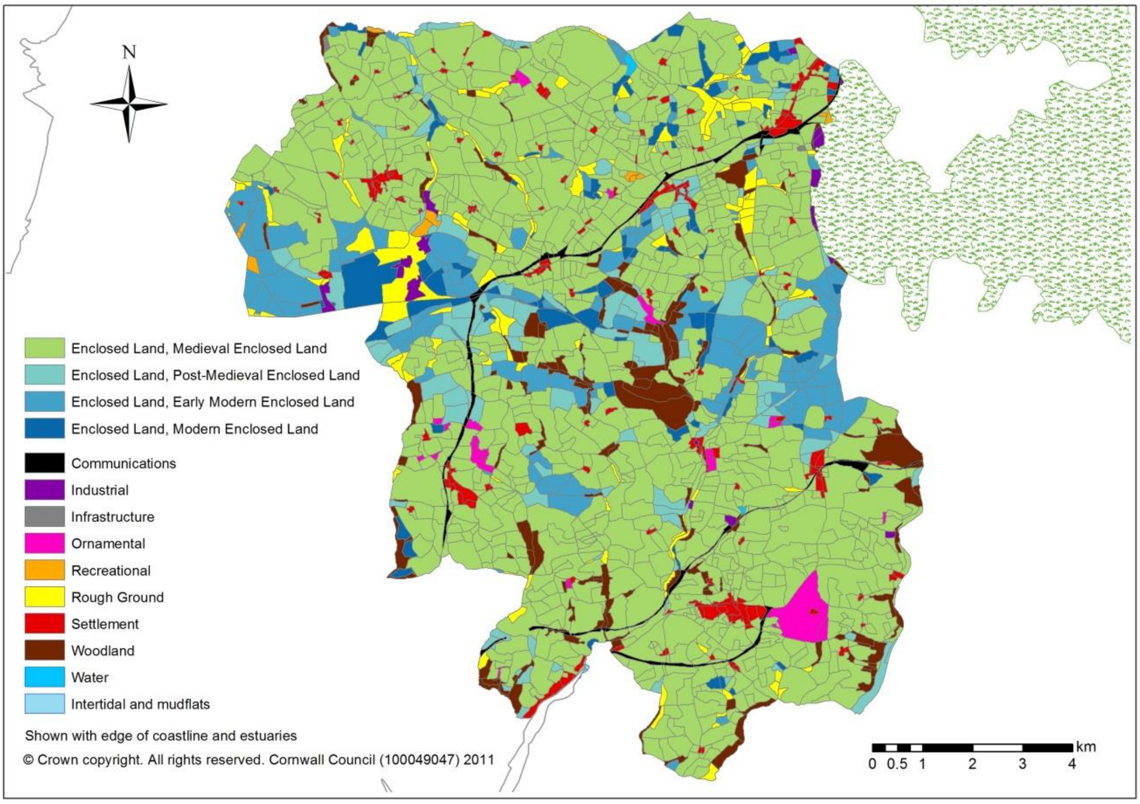

Fig 31. Probus study area: 2011 deepened HLC showing broad Types, and HLC Types for Enclosed Land.

The four time-slices in the Lowland Cornwall HLC reveal how the area (sq km) of each of the main HLC Types has changed over time, reflecting changing land use patterns. This is shown below. The final column shows the difference in area between Late Medieval and 2011 time-slices.

Refined HLC Sub-Type	2011	1880	1840	Late Medieval	Difference
Medieval Enclosed Land	89.894	93.223	93.971	95.974	-6.08
Post-Medieval Enclosed Land	8.560	9.630	10.247	0	8.560
Early Modern Enclosed Land	12.054	12.620	8.667	0	12.054
Modern Enclosed Land	4.648	0	0	0	4.648
Rough Ground	5.363	10.353	14.376	33.040	-27.677
Woodland	5.740	5.383	5.046	5.679	0.061

Table 42. Probus study area: comparison of time-slices (figures in km sq).

Clearly the growth of Post-Medieval Enclosed Land and, more recently, Early Modern and Modern Enclosed Land has been primarily at the expense of Rough Ground.

The time-slices also show land use developments within the medieval enclosure types. The striking change is the amount of alteration to fields derived from cropping units (a cropping unit comprises a group of open strip fields which has been enclosed at a later date to form a single larger field), which are interpreted as taking up 86 sq km at the end of the medieval period, but which now only cover 22.5 sq km. This 75% reduction results from episodes of extensive sub-division prior to 1840, continuing until the twentieth century when they seem to have tailed off. During the twentieth century there has been a dramatic alteration to fields derived from cropping units through widespread amalgamation of fields. Only small areas of fields derived from strip fields and peripheral fields were identified and the present day extent of these has shrunk to less than a square kilometre.

Refined HLC Sub-Types	2011	1880	1840	Late Medieval
MD Altered field patterns (Amalgamated)	44.293	13.988	1.266	0
MD Altered field patterns (Re-arranged)	12.367	8.122	8.060	0
MD Altered field patterns (Sub-Divided)	9.943	21.097	27.480	0
MD derived from Cropping Units	22.515	45.725	51.052	85.636
MD derived from Strip Fields (Enclosed)	0.391	3.491	3.970	6.967
MD peripheral fields	0.385	0.800	2.143	3.371
Total (sq km)	**89.894**	**93.223**	**93.971**	**95.974**

Table 43. Probus study area: area of Medieval Enclosed (MD) Land Sub-Types for each time-slice (figures in km sq).

11.4 Penwith

The Penwith study area is located in the far west of Cornwall (Fig 29) and covers 93.838 sq km, including approximately 23 km of coastline around Mounts Bay (Fig 32).

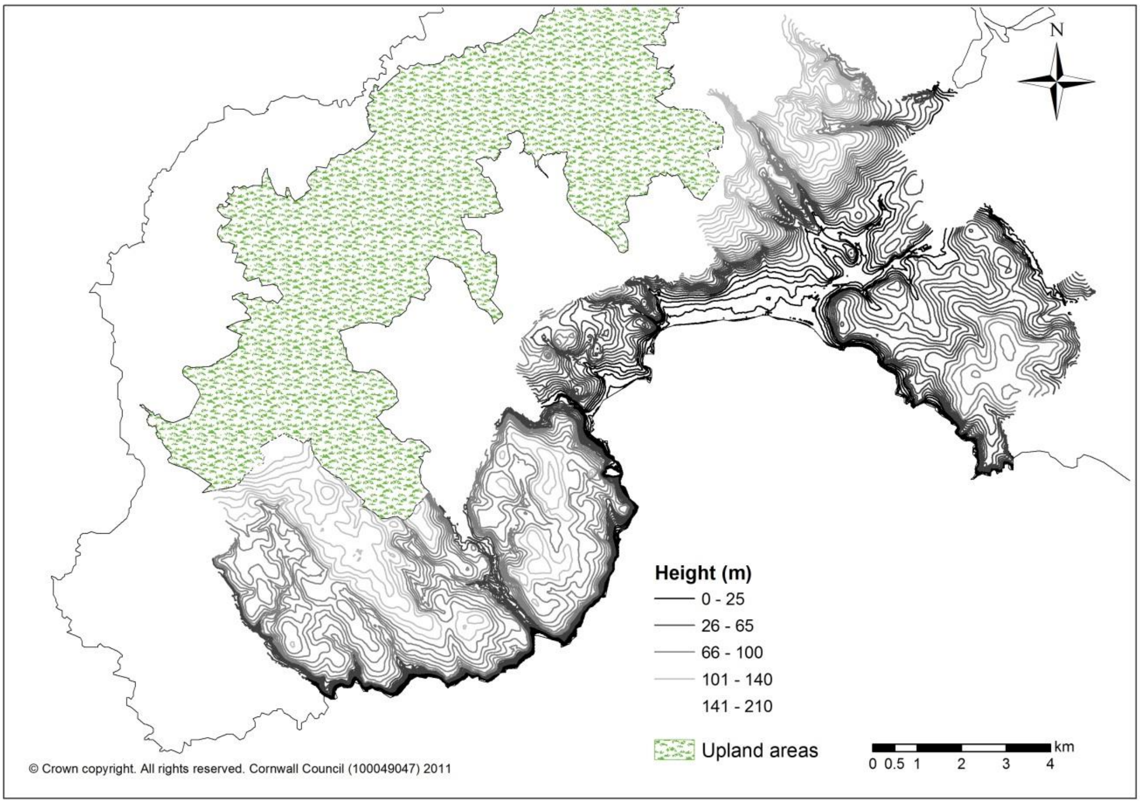

Fig 32. Penwith study area shown with contours.

Much of the land located on the eastern edge of the Mount's Bay, in the parishes of St Hilary, Perranuthnoe, Marazion and Penzance, is low lying (below the 65m contour). This includes the area of Marazion Marsh, a large open area of pools and rushes, which extends inland before narrowing into a river valley.

Where the area overlies the West Penwith granite the ground rises to a higher elevation as the slopes heighten to the ridge that forms the backbone of the peninsula. In the northern parts of Ludgvan and St Buryan, the area includes high ground, including Trencrom Hill (170m) and the shoulder of Carn Brea (175m), with the summit of Trink Hill, near Nancledra, Ludgvan, forming the highest point at 210m.

The granite area is characterised by a drainage pattern of stream valleys that run in a general northwest – southeast orientation. The eastern boundary of St Hilary parish, and the study area, is defined by the River Hayle, a prominent landscape feature in the area.

There is a discrepancy in the size of the study areas of the 1994 and 2011 HLC mapping. The 2011 HLC is larger, extending further into the intertidal zone than that of 1994. A comparison of the percentage of the study area taken up by each HLC Type in the 1994 and the equivalent deepened 2011 HLC is shown in Table 44.

HLC Type	% Area (1994)	% Area (2011)
Communications	1.02%	0.85%
Prehistoric Enclosed Land	40.62%	7.53%
Medieval Enclosed Land	18.27%	51.68%
Post-Medieval Enclosed Land	13.00%	6.39%
Modern Enclosed Land (incl. Early Modern)	8.31%	11.98%
Industrial	0.69%	0.53%
Intertidal and inshore water	0.22%	1.99%
Ornamental	0.32%	0.68%
Plantations and Scrub	2.97%	0.43%
Recreational	0.20%	0.24%
Settlement	6.70%	8.48%
Coastal Rough Ground	2.43%	1.88%
Upland and Valley Rough Ground	5.11%	5.71%
Water	0.07%	0.06%
Woodland	0.06%	1.56%

Table 44. Penwith study area: comparison between 1994 and 2011 HLC

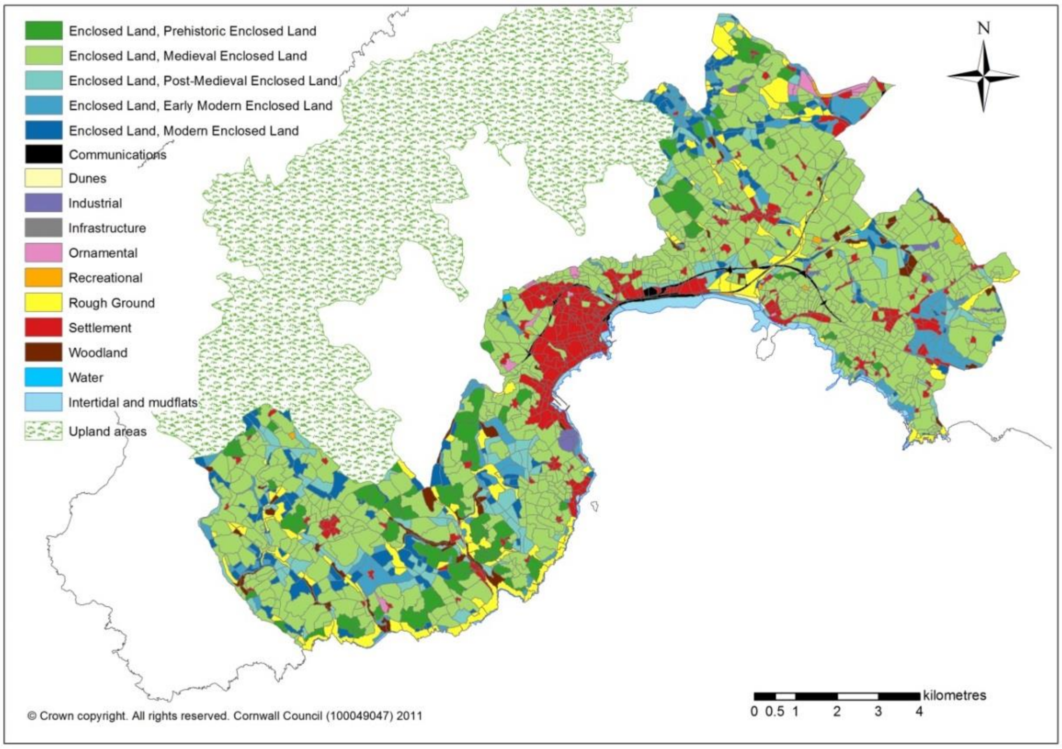

Fig 33. Penwith study area: 2011 deepened HLC showing Broad Type, and HLC Types for Enclosed Land.

The biggest difference is that much of the land classed as Prehistoric Enclosed Land in the 1994 HLC has been re-interpreted as Medieval Enclosed Land in 2011. Roughly half the area classed as Post-Medieval Enclosed in 1994 has been re-interpreted as Modern Enclosed Land (including Early Modern Enclosed Land) or as Medieval Enclosed Land (Fig 33).

The four time-slices in the revised HLC reveal how the area of each of the main HLC Types has changed over time, reflecting changing land use patterns. This is shown in Table 45. The final column shows the difference in area between the Late Medieval and 2011 time-slices.

Refined HLC Type	2011	1880	1840	Late Medieval	Difference
Prehistoric Enclosed Land	7.064	6.987	7.196	7.058	0.006
Medieval Enclosed Land	48.497	51.381	52.716	55.271	-6.774
Post-Medieval Enclosed Land	5.994	6.796	6.966	0	5.994
Early Modern Enclosed Land	5.630	6.551	5.225	0	5.630
Modern Enclosed Land	5.614	0	0	0	5.614
Rough Ground	7.061	14.277	15.819	28.268	-21.207
Woodland	1.460	0.125	0.000	0.299	1.161

Table 45. Penwith study area: comparison of time-slices (figured in sq km).

The area of Prehistoric Enclosed Land has remained fairly consistent throughout the time-slices, probably because it is often found in marginal locations, though it has often undergone phases of alteration. At the time of the 1880 time slice a small area of Prehistoric Enclosed Land had become so overgrown that it was classed as Rough Ground: by 2011 this land had been cleared and taken back into agriculture so that its character was once again prehistoric enclosure. Clearly the growth of Post-Medieval Enclosed and, more recently, Early Modern and Modern Enclosed Land has been primarily at the expense of Rough Ground.

The time-slices also show land use developments within the Medieval (MD) Enclosed Land HLC and its Sub-Types. Ninety three percent of land classed as cropping units in the Late Medieval time-slice and 97% of strip fields (whether enclosed or unenclosed) have been altered. The alteration process was characterised by sub-division until the late nineteenth century and since then by amalgamation (Table 46).

Refined HLC Types	2011	1880	1840	Late Medieval
MD Altered field patterns (Amalgamated)	26.534	16.848	0.063	0
MD Altered field patterns (Re-arranged)	10.575	8.053	10.581	0
MD Altered field patterns (Sub-Divided)	8.013	16.431	26.644	0
MD derived from Cropping Units	3.045	8.575	13.069	46.151
MD derived from Strip Fields (Enclosed)	0.195	1.212	1.764	6.910
MD peripheral fields	0.136	0.262	0.537	2.152
MD strips (Unenclosed)	0	0	0.057	0.057
Total (sq km)	**48.497**	**51.381**	**52.716**	**55.271**

Table 46. Penwith study area: area of Medieval Enclosed Land Sub-Types for each time-slice (figures in sq km).

11.5 Pelynt

The Pelynt study area is located on the south coast of Cornwall (Fig 29), on and around the Fowey estuary, and in total covers an area of 89.155 sq km. It includes a six km stretch of coastline characterised by moderately high cliffs and steep cliff slopes, stretching between Lansallos in the east and almost as far as Gribbin Head in the west (Fig 34).

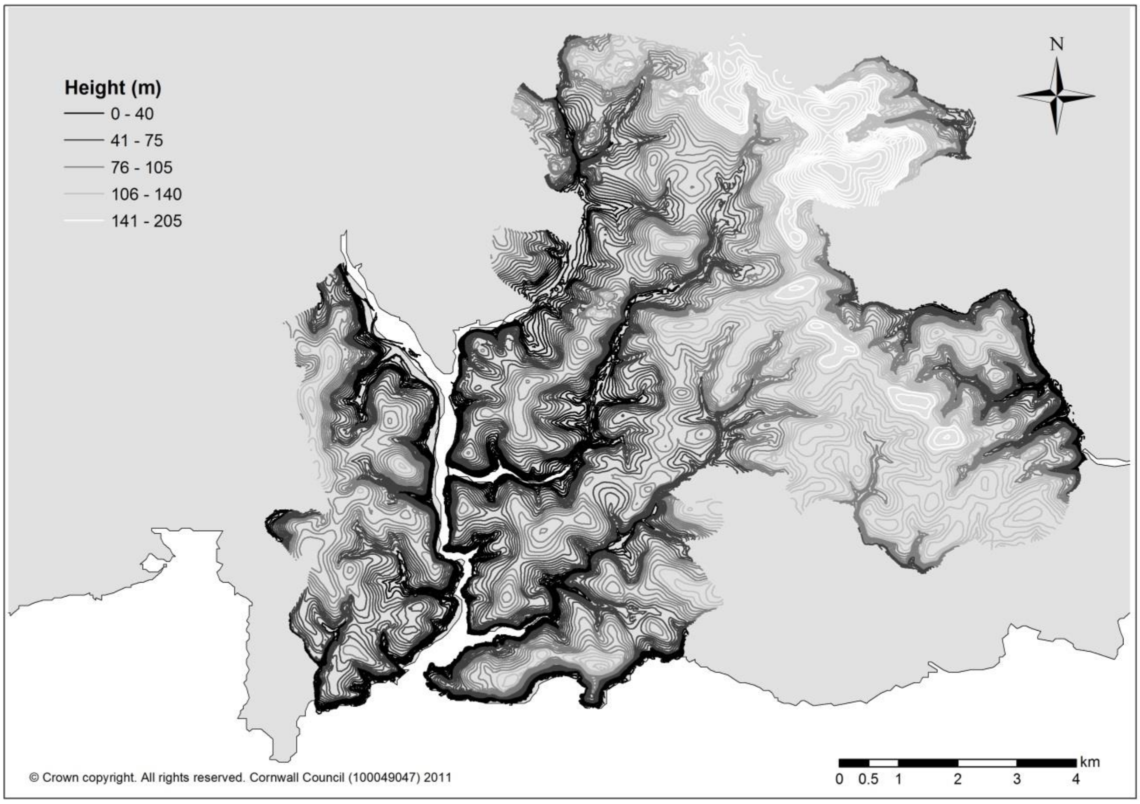

Fig 34. Pelynt study area showing contours.

The Fowey estuary cuts inland from the coast leading to a series of tributaries, most notably the River Lerryn and Trebant Water. These rivers extend inland to form a dendritic drainage pattern and a predominantly undulating landscape of ridges incised by steep-sided valleys. The valleys often form the boundaries of parishes; the east of the study area for example is bounded by the West Looe River, which forms the eastern edge of the parish of Pelynt.

Close to the rivers, much of the western part of the area is relatively low-lying, generally situated below the 100m contour. However, ridges of higher ground extend from the eastern edge of the Fowey estuary, leading eastward to a large ridge of higher ground that runs roughly south-north, reaching its highest point in the north eastern part of the study area at Bury Down (205m). The northernmost section of the study area occupies the flank of the high ground of Braddock Down.

A comparison of the percentage of the study area taken up by each HLC Type in the 1994 and the equivalent deepened 2011 HLC is shown in Table 47.

HLC Type	**% Area (1994)**	**% Area(*c*2011)**
Coastal Rough Ground	0.57%	0.89%
Communications	0.19%	0.19%
Industrial	0.13%	0.15%
Medieval Enclosed Land	53.01%	67.84%
Post-Medieval Enclosed Land	26.57%	7.16%
Modern Enclosed land	1.27%	5.87%
Mudflats and inshore water	2.24%	2.00%

HLC Type	% Area (1994)	% Area(*c*2011)
Parkland	3.09%	1.38%
Plantation	0.28%	1.88%
Recreational	0.39%	0.48%
Settlement	2.66%	2.59%
Upland and Valley Rough Ground	1.47%	1.50%
Woodland	8.13%	8.08%

Table 47. Pelynt study area: comparison between 1994 and 2011 HLC.

The significant difference is in the interpretation of Post-Medieval Enclosed Land. In the 1994 HLC 23.69 sq km is classed as Post-Medieval whereas in the 2011 HLC the figure is only 6.38 sq km. The difference is 17.31 sq km, of which 4.1 sq km was re-interpreted as Modern or Early Modern Enclosed Land and 13.2 sq km as Medieval Enclosed Land in the 2011 HLC.

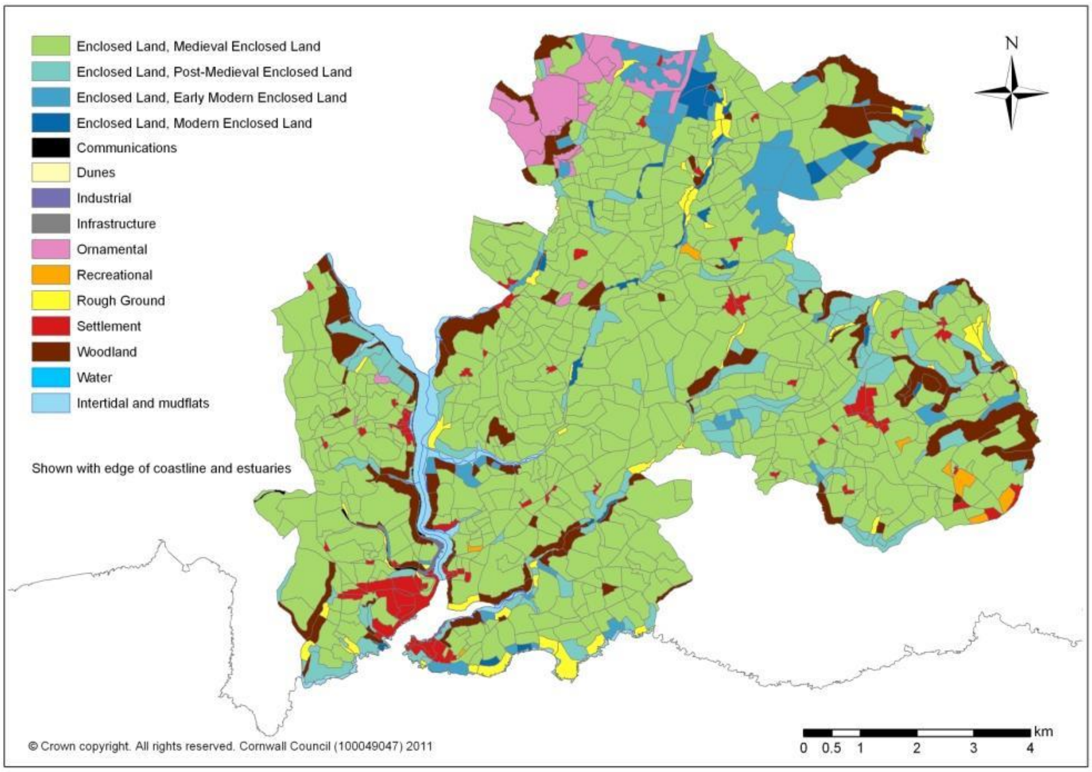

Fig 35. Pelynt study area: 2011 deepened HLC.

The four time-slices in the deepened HLC reveal how the area of each of the main HLC Types has changed over time, reflecting changing land use patterns. This is shown below. The final column shows the difference in area between the late medieval and 2011 time-slices.

Deepened HLC Type	2011	1880	1840	Late Medieval	Difference
Medieval Enclosed Land	60.487	62.653	62.897	64.629	-4.143
Post-Medieval Enclosed Land	6.380	7.202	7.513	0	6.380
Early Modern Enclosed Land	4.100	4.682	1.847	0	4.100
Modern Enclosed Land	1.131	0	0	0	1.131
Rough Ground	1.336	2.379	4.015	8.176	-6.839
Woodland	7.201	5.573	6.150	12.586	-5.385

Table 48. Pelynt study area: comparison of time-slices (figures in sq km).

This shows that the extent of Rough Ground, Woodland and Medieval (MD) Enclosed Land has diminished through time. The time-slices also show land use developments within the medieval enclosure types.

Deepened HLC Sub-Type	2011	1880	1840	Late Medieval
MD Altered field patterns (Amalgamated)	33.21	19.81	1.02	0.00
MD Altered field patterns (Re-arranged)	15.78	9.32	11.85	0.00
MD Altered field patterns (Sub-Divided)	7.67	20.89	32.84	0.00
MD derived from Cropping Units	3.43	10.97	14.34	54.42
MD derived from Strip Fields (Enclosed)	0.07	0.56	1.19	6.65
MD peripheral fields	0.33	1.10	1.65	3.55
Total (sq km)	**60.49**	**62.65**	**62.90**	**64.63**

Table 49. Pelynt study area: area of Medieval Enclosed Land Sub-Types for each time-slice (figures in sq km).

11.6 Poundstock

The Poundstock study area is located in the north-eastern corner of Cornwall (Fig 29). Originally it was planned to include Week St Mary parish in this study area but no digitised Tithe map data was available so this parish was omitted. As a result the study area encompasses a less contiguous block of landscape than the other three and is the smallest, covering an area of 65.574 sq km (Fig 36).

The eastern parish boundaries of both Marhamchurch and Whitstone form part of the boundary with Devon which is defined by the River Tamar. The western boundary of Jacobstow follows the River Ottery as it runs southeast. The parish of Marhamchurch is dissected by the River Neet, which also forms part of the eastern parish boundary of Poundstock. Poundstock is also cut by the Wanson Water and Millook Water as they flow from higher ground to the coast

The study area includes approximately five kilometres of coastline around Widemouth Bay. Much of this coast is relatively low-lying (below the 50m contour), apart from in the south around Millook, where the land quickly rises to the 120m contour.

Although the Neet valley is steep-sided, much of Marhamchurch is relatively low-lying. Only in the far east of the parish does the land rise above the 70m contour. The northernmost portion of Poundstock parish is similarly low-lying but in the south the land rises and continues to do so into Jacobstow parish, most of which lies above the 70m contour. The southern part of Jacobstow is characterised by a long and prominent ridge running northwest – southeast to Langdon Hill on the 145m contour. Whitstone is also hilly, being formed by an undulating plateau which drops away steeply to the valleys of the Tamar in the east and a tributary of the Neet in the west. The western part of the plateau is characterised by a north-south line of rounded hills which reach the 160m contour at Whitstone itself.

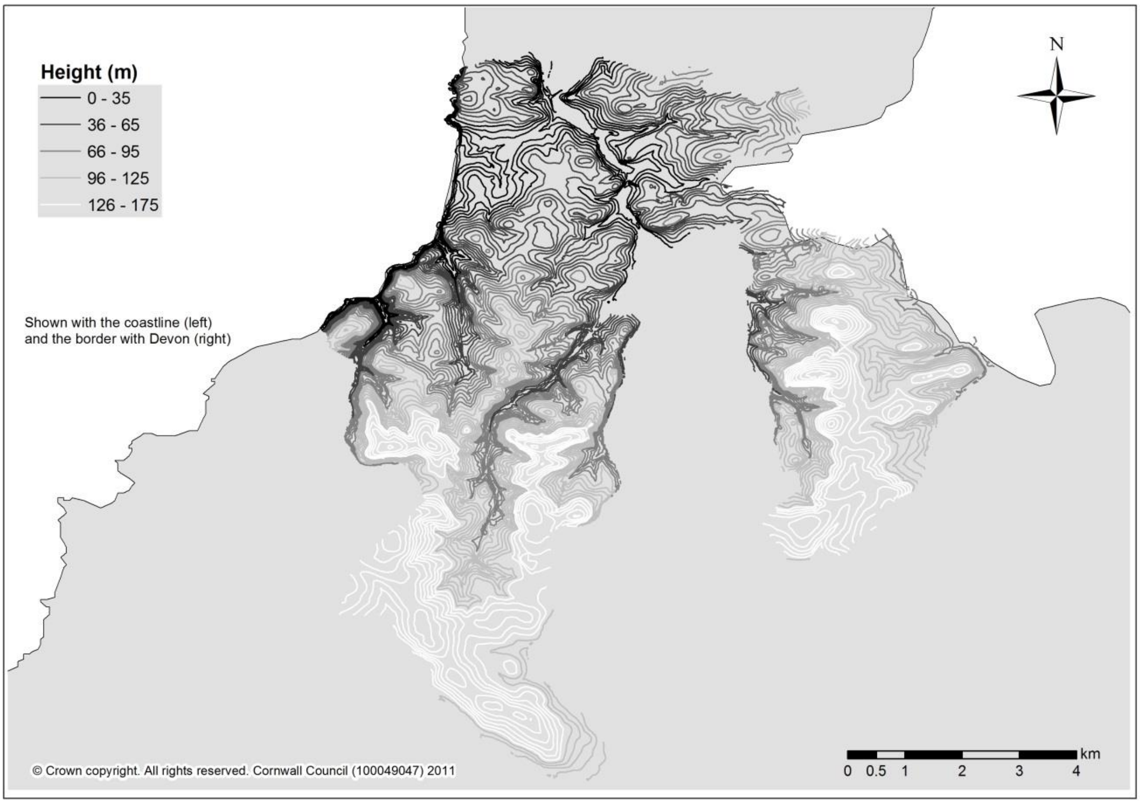

Fig 36. Poundstock study area showing contours.

A comparison of the percentage of the study area taken up by each HLC Type in the 1994 and the equivalent deepened 2011 HLC is shown in Table 50.

Deepened HLC Type	% Area 1994	% Area 2011
Coastal Rough Ground	1.50%	0.87%
Communications	0.31%	0.31%
Medieval Enclosed Land	52.71%	60.36%
Post-Medieval Enclosed Land	20.38%	9.21%
Modern Enclosed Land (incl. Early Modern)	14.12%	17.65%
Industrial	0.02%	0.02%
Intertidal and inshore water	1.82%	2.43%
Military	0.12%	0.12%
Plantations and Scrub	0.74%	0.74%
Recreational	0.55%	0.55%
Settlement	2.37%	2.37%
Upland and Valley Rough Ground	1.20%	1.21%
Woodland	4.15%	4.16%

Table 50. Poundstock study area: comparison between 1994 and 2011 HLC.

The biggest difference is that 11% less of the area is interpreted as Post-Medieval Enclosed Land. Roughly 3.5% has been re-interpreted as Modern or Early Modern Enclosed and 7.5% as Medieval Enclosed Land.

The four time-slices in the deepened HLC reveal how the area of each of the main HLC Types has altered over time, reflecting changing land use patterns. This is shown below in Table 51. The final column shows the difference in area between medieval and present.

Deepened HLC Type	2011	1880	1840	Late Medieval	Difference
Medieval Enclosed Land	39.583	39.983	41.542	42.302	-2.719
Post-Medieval Enclosed Land	6.039	6.368	6.739	0	6.039
Early Modern Enclosed Land	2.385	2.469	0.435	0	2.385
Modern Enclosed Land	9.187	0	0	0	9.187
Rough Ground	1.362	13.076	13.542	18.920	-17.558
Woodland mixed	2.726	1.746	1.406	2.640	0.086

Table 51. Poundstock study area: comparison of time-slices.

Clearly the growth of Post-Medieval Enclosed and, more recently, Early Modern and Modern Enclosed has been primarily at the expense of Rough Ground.

The time-slices also show land use developments within the medieval (MD) enclosure types (Table 52).

Deepened Sub-Type	2011	1880	1840	Late Medieval
MD Altered field patterns (Amalgamated)	24.205	13.416	0.875	0
MD Altered field patterns (Re-arranged)	9.883	10.006	12.789	0
MD Altered field patterns (Sub-Divided)	3.373	9.942	16.792	0
MD derived from Cropping Units	1.902	5.363	8.334	29.057
MD derived from Strip Fields (Enclosed)	0.082	0.491	1.414	10.266
MD peripheral fields	0.138	0.766	1.338	2.978
Total (sq km)	**39.583**	**39.983**	**41.542**	**42.302**

Table 52. Poundstock study area: area of Medieval Enclosed Land Sub-Types for each time-slice.

Seventy two percent of land classed as cropping units in the Late Medieval time-slice and 90% of enclosed strip fields had been sub-divided or re-arranged by the 1840 time-slice. Since 1840 the process of alteration has been one of amalgamation. Now there are hardly any strip fields left and less than two sq km of 'derived from Cropping Units'.

11.7 Lowland Cornwall HLC: an overview

At the same time as providing essential information for the finer-grained predictive models for the four study areas, the Lowland Cornwall HLC can also be seen as a stand-alone project. Indeed, further HLC projects broadly based on its methodology carried out since its completion have led to the whole of West Penwith being mapped at a finer grain than the 1994 HLC. A number of important points arising from the HLC methodology and the results of the mapping are outlined here.

11.7.1 Using Historic Settlement data

Place-name mapping was used to provide further context to the interpretation of the landscape. The dataset was produced for each parish before HLC mapping was undertaken. The potential for dating certain Cornish and English place-name elements enabled a greater degree of confidence in the interpretation of an area's HLC. It also included the form and type of the settlement named, and a mid-18th century time-slice based on Martyn's 1748 'Map of Cornwall'. Consultation of Martyn's map also provided further context to the HLC mapping, increasing confidence in the differentiation of 'Post-Medieval' from 'Early Modern' Enclosed Land as the map accurately records the extents of larger areas of unenclosed rough ground in 1748. For clarity, the year 1750 was used as the cut-off between post medieval and early modern periods.

Interpretation of the place-name mapping was also used in an attempt to indicate the continuity of settlement and land use of each area. For example, the enclosed land surrounding a *tre-* settlement would be identified as 'Core'. The identification of attribute values as either 'Core', 'Sub-core', 'Fluctuating/Tidal' and 'Marginal' aimed to indicate the potential depth of continuous land use in an area.

The purpose of these attributes was to add value to the predictive models: to see if the archaeological resource in areas of potential continuous settlement since the late prehistoric period (Core) differed from that in more peripheral areas. Decision making for 'Landuse' values was based on the interpretation and dating of Cornish and, to a lesser extent, English place-name elements contained in the Historic Settlement dataset. These were used to give a potential indication of a settlement's earliest date, and the landscape history of the area.

This is easiest to postulate for the Cornish place-name elements *tre, bod, hendre, lann, ker* and *lys* which probably date in usage to between the fifth and tenth centuries AD (Padel 1985). It is suggested that these could be interpreted as 'Core' areas: those most likely to have been continuously settled since the Romano-British period. The polygons surrounding these settlements were classified as 'Core'.

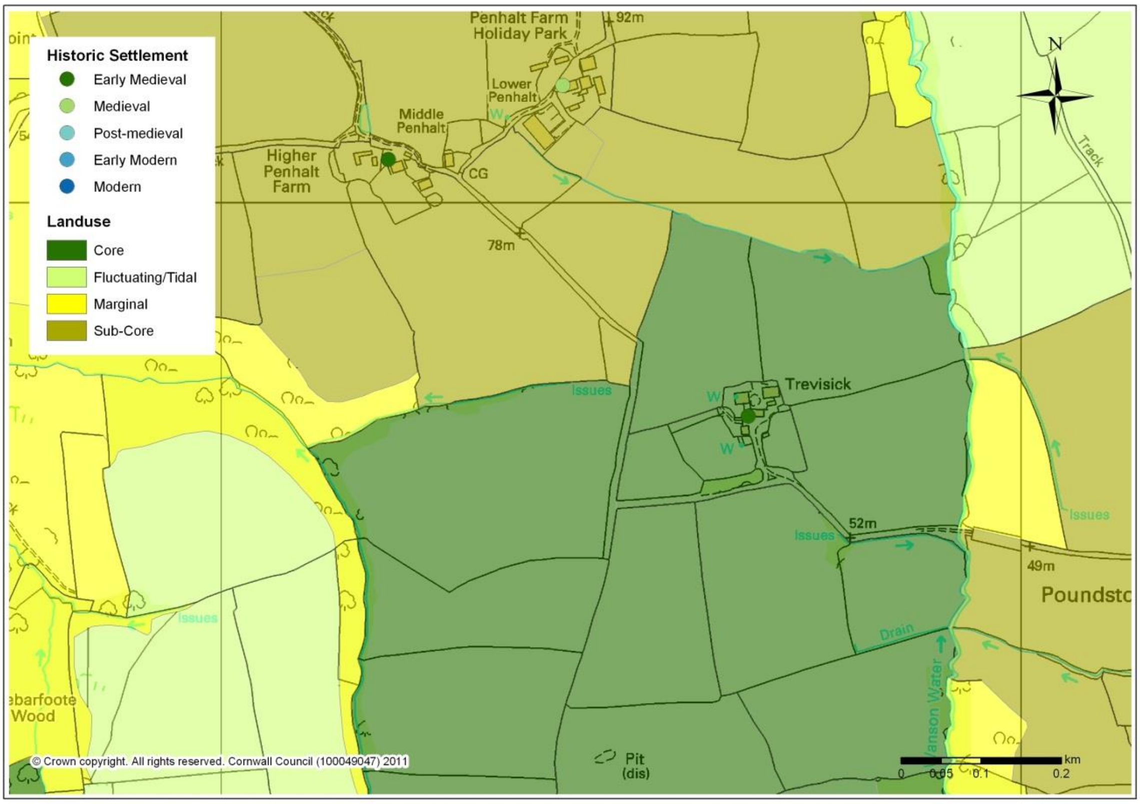

Fig 37. Poundstock study area: Identification of 'Landuse' in areas surrounding settlements of early medieval date. Trevisick was dated on its Cornish tre- place-name element but Penhalt was recorded as early medieval due to its documentation by the Domesday Book in 1085 as an important estate.

Other attribute values for Landuse included 'Sub-Core' (possible areas of continuous settlement) and 'Fluctuating/Tidal' (areas which may have seen an extension of settlement in the late prehistoric/early historic period, then a retraction of settlement, followed by colonisation again, sometimes in slightly different locations and potentially under different circumstances, in the later medieval period). 'Marginal' Landuse was identified on the basis of rough ground, altitude, severity of slope and aspect; typically corresponding with Rough Ground or Woodland, or previous areas of Rough Ground (Post-Medieval, Early Modern and Modern Enclosed Land) and Woodland.

Accurately establishing the extent to which a group of fields were associated with a given settlement was difficult. Extent was usually established by subjective judgment influenced by topography (altitude, severity of slope, and aspect) and the way in which the landscape was divided (dominant boundaries). A small number of the 1840 Tithe maps recorded tenement boundaries (for example, Paul) and where so, these were used to delineate the areas of enclosed land surrounding a particular settlement.

11.7.2 Differentiation between Prehistoric and Medieval Enclosed Land

During the 1994 HLC no Prehistoric Enclosed Land was recorded east of a rough line between Hayle and Marazion, although the possibility that some parishes elsewhere might also contain tracts of this land class was suggested at the time (Herring 1998). One of the positive outcomes of the Lowland Cornwall HLC mapping was that this was indeed found to be the case, with Prehistoric Enclosed Land identified in the ecclesiastical parish of Perranuthnoe and in the eastern part of Marazion parish (both within the Penwith study area), although in total this amounted to a little more than 20ha.

Prehistoric Enclosed Land was distinguished by a predominance of erratic and/or curvilinear field boundaries and small field size. However, the 2011 time-slice contains no areas of Prehistoric Enclosed Land that have not been altered in some way. For many areas these alterations have been so comprehensive that their prehistoric attributes have been lost. However, these areas were classed as altered Prehistoric Enclosed Land in 2011 following their initial identification in 1840 and 1880 using the Tithe and OS maps as evidence.

Due to the survival of Prehistoric Enclosed Land here, Penwith can be seen as different from the other study areas. However, as with the other study areas, most of Penwith was characterised as Medieval Enclosed Land (51.68% of the area). This is quite different to the 1994 HLC mapping when 18.27% of the Penwith study area was characterised as Medieval Enclosed Land, and 40.62% as Prehistoric Enclosed Land.

The most obvious reasons for this difference are the approach of the person undertaking the HLC mapping and the subjective role involved in HLC mapping. It is clear that the Lowland Cornwall initial approach to mapping differed from that of the HLC team in 1994. In the 2011 refined HLC it was felt that the Prehistoric Enclosed Land could only be identified where it was substantially visually different in terms of boundary form from Medieval Enclosed Land. While it was clear as mapping progressed that the character of Medieval Enclosed Land in Penwith 'felt' different from the other study areas, especially in its more marginal locations, it was decided that in many instances it was nearer to a medieval character rather than the surviving prehistoric character found elsewhere.

At Cargoll, Newlyn East, for example, the curvilinear elements in the boundaries were mapped as only a minor part of the landscape, the area being dominated by sinuous boundaries (Fig 38). The SMR point records the remains of a prehistoric enclosure, partially fossilised in the field boundary and partially surviving as an earthwork (PRN 25050). The area also contains another enclosure recorded as a banked feature (PRN 55558). The curvilinear nature of this feature appears to be partially mirrored in the nearby field boundary. Its identification as Medieval Enclosed Land and not Prehistoric is because the prehistoric features are not dominant parts of the landscape, with only limited elements fossilised in all three time-slices. Such limited features can only confirm that prehistoric activity occurred in the area, not that the area is entirely or predominantly fossilised prehistoric enclosed land.

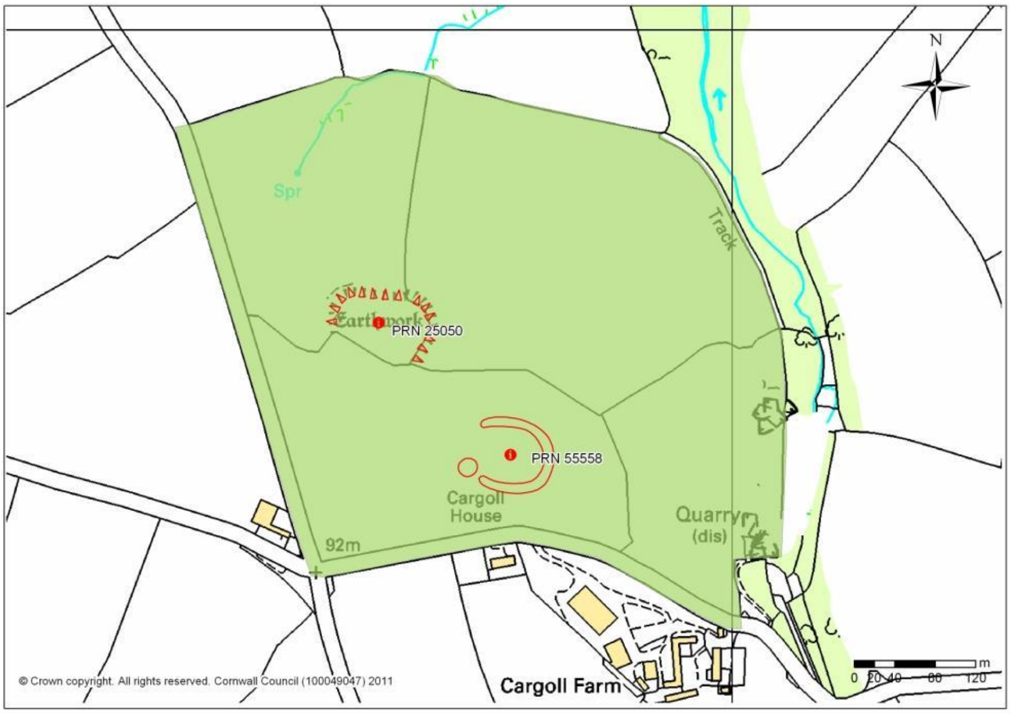

Fig 38. Probus study area: Cargoll, St Newlyn East, Medieval Enclosed Land with limited prehistoric features fossilised in field boundaries. *Shown with NMP data (red lines) and SMR points.*

11.7.3 Differences in the HLC of the four study areas

An analysis of Medieval Enclosed Land in relation to dominant and secondary boundary types suggested only limited differences between the study areas. Overall 'Very Irregular' field patterns are more frequent in the Penwith and Pelynt study areas; with 34% and 42% respectively located in each area. Dog-leg shaped boundaries are more likely in Probus, Pelynt and Poundstock and erratic boundaries most likely in Penwith, both as dominant and secondary characteristics. However, erratic boundary types are not exclusive to Penwith as they are also a result of the amalgamation of medieval field boundaries across all study areas and not solely a fossilisation of prehistoric elements.

A noticeable feature of Penwith is the large number of polygons in the study area compared with the other three. The mapping rate for Penwith was noticeably slower than the other study areas, suggesting a more complex and varied landscape. The higher number of polygons is also due to the smaller size of fields in Penwith, and small mean field size is a marked difference which sets Penwith apart from the other study areas.

The average field size for Enclosed Land of all dates is noticeably smaller in Penwith, and over half the size of that found in the Probus study area, where field size is largest. Fields in the Poundstock area are also noticeably smaller.

Study Area	**Mean hectarage of a field**
Probus	2.95
Pelynt	2.64
Poundstock	2.16
Penwith	1.36

Table 53. Mean hectarage of fields in Enclosed Land for the four study areas.

Further analysis of the Prehistoric Enclosed Land identified in Penwith shows a mean value of 1.35ha per field, increasing to 1.44ha where 'altered' or 're-arranged' and an extremely small 0.68ha where 'sub-divided'. When only Medieval Enclosed Land is analysed across all the study areas, Penwith is again noteworthy for its difference in mean field size.

Study Area	Mean hectarage of a field
Probus	2.95
Pelynt	2.63
Poundstock	2.16
Penwith	1.41

Table 54. Mean hectarage of fields in Medieval Enclosed Land for the four study areas

This suggests that the fields making up Medieval Enclosed Land in Penwith are quite different in hectarage than those in the other study areas. The mean figure of 1.44ha field size for altered Prehistoric Enclosed Land is very close to the mean figure of 1.41ha field size for Medieval Enclosed Land in Penwith. It is unclear if this is a difference which dates back as far as the prehistoric period, and that Penwith has always been enclosed (and farmed) differently, or if this is simply a difference in the date and mechanism of later changes, or a combination of the two. The difference in the Penwith landscape in the 19th century was, in part, due to differences in the arrangement of its settlements and land holdings. The smaller size of fields in the Poundstock area could be due to the poor soils, or a difference in the way the area is, and has been, farmed.

Probus is also markedly different from the other study areas. Here the agricultural landscape appeared to be organised on a larger scale from an earlier date than elsewhere. This was particularly true in the parish of Probus and the southern portions of Ladock and St Erme. Here, the Historic Settlement data can be of some use. In 1748 20 of the 84 Mansion Houses recorded in the project area were located around Probus, Ladock and Trispen (in an area approximately 58 sq km in size). Probus was also known as the 'garden parish' of Cornwall renowned for its fertility and favourable climate. By 1840 the same area contained 27% of the mansion houses and by 1880, 25%. The wealth of the area may have also been affected by its close proximity to Truro, a centre for merchants and business. However, it seems that holdings in the Probus area were amalgamated at an early date, perhaps as early as the late medieval period in some instances.

11.7.4 Interrelation of Medieval Enclosed Land with later enclosure

Whilst the Lowland Cornwall project aimed at better understanding the interaction of prehistoric and medieval enclosed land, the HLC mapping also provided hints at an interesting interaction between Post-Medieval and Early Modern Enclosed Land and earlier medieval features. A data query for Post-Medieval Enclosed Land where the dominant boundary is sinuous returned 58 records. In the 2011 time-slice a majority of these areas had been altered. But by looking at the 1840 time-slice it was clear that a majority of this land was identified as the Sub-Type, 'Post-Medieval Intakes' – the enclosure of rough ground - (51 areas; 88%). In 24 of these 51 areas sinuous boundaries were dominant in 1840. These areas are often located on the edges of existing medieval field systems, in more marginal locations such as valley bottoms, or near the edges of cliffs and valley sides. Interpretation suggests that the sinuous boundaries are remnants of earlier, medieval use but in a temporary or less intensive arrangement: the boundaries on steep sided valleys probably the remnants of wood banks or pasture boundaries (that follow breaks in the slope or natural features); those in valley bottoms are perhaps the remnants of leats, or pasture boundaries again making use of natural features, and on cliff edges and hill slopes these may re-use areas of former temporary outfield cultivation or pasture boundaries. The classification of these areas as 'Post-Medieval' rather than 'Medieval' is due to their marginal location, away from the permanently enclosed land surrounding the medieval settlements.

11.7.5 Boundary loss and gain

Establishing the number of fields for three time-slices enabled a general understanding of boundary loss and gain. Overall, for the areas presently identified as Enclosed Land, there was an approximate 42% loss in field boundaries between 1840 and 2011. The overall rate is about the same in the Pelynt study area, slightly less in Penwith and Probus and slightly higher in Poundstock. However, the highest single loss of field boundaries was recorded in an area at Higher Treave, St Buryan, where there was a 96% reduction (Fig 39). Penwith was also the location for the greatest increase in field boundaries, where an area of rough ground was enclosed and sub-divided into market garden plots; an increase from two boundaries in 1840 to 44 in 2011 (Fig 39).

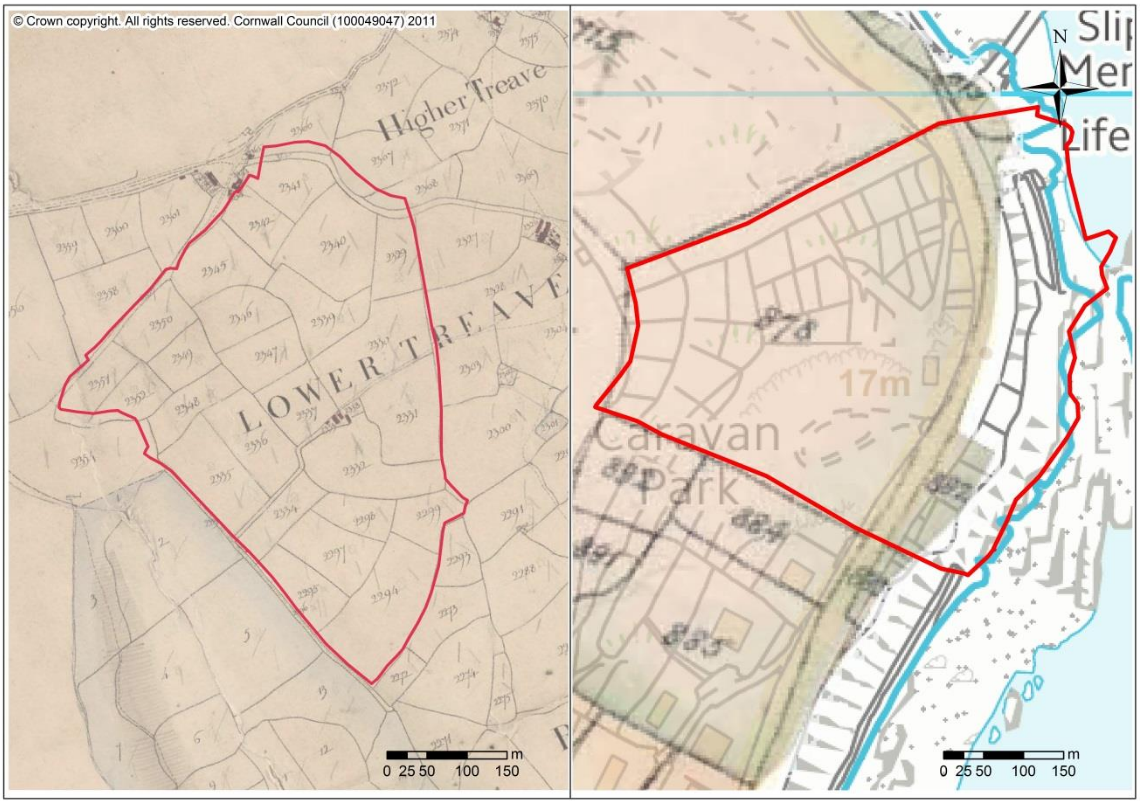

Fig 39. Areas with the greatest loss and gain of fields. The greatest loss of fields was recorded at Treave, St Buryan (left) and the largest gain of fields at Penlee Point, Paul (right) between the 1840 and 2011 time-slices. Both areas are shown with the 1840 Tithe Map and modern OS 1:10,000 mapping.

The deepened HLC suggests that there has been a mean 50% loss in the numbers of field boundaries since 1840 in Medieval Enclosed Land, and an 80% loss in the Altered Sub-Types.

Analysis of boundary loss/gain could help increase the understanding of landscape change upon HLC. It is possible that there are noticeable differences between time-slices and areas. Further assessment of the results could establish the usefulness of the data to guide future landscape strategy in Cornwall, and further develop our understanding of where change has occurred and is likely to happen in future.

11.7.6 Landscape change over time

An advantage of Lowland Cornwall's three time-slices is that they give a clearer indication of the extent of landscape change that has occurred in many areas. It is interesting to note that certain areas of Medieval Enclosed Land are now more 'medieval' in character than they were in 1840. Many of the fields surrounding St Newlyn East had been sub-divided in 1840, probably due to the rise in population from the success of the mines in the area. By 1880 many of the fields were still sub-divided, notable for the small fields and straight boundaries dividing former medieval cropping units. By 2011 many of these smaller, later sub-divisions had been removed, resulting in a return to enclosures derived from cropping units. Because of the sequential nature of the Lowland Cornwall HLC these areas were recorded in the present 2011 HLC as 'MD Altered field patterns (Amalgamated)' (Fig 40).

Fig 40. Probus study area: the area to the north of the settlement of St Newlyn East, shown in the late medieval, 1840, 1880 and 2011 time-slices (anti-clockwise from top left).

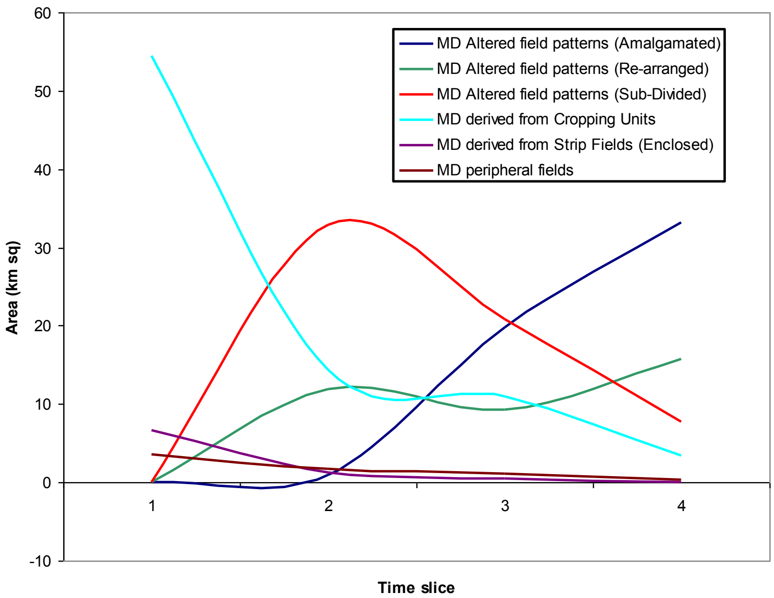

Fig 41. Pelynt study area: graph showing changes to Medieval Enclosed Land over the four time slices.

In fact, one of the important results from the deepening of HLC is the recognition that this pattern of change appears to be county-wide. In all four study areas many of the former cropping units had been sub-divided by 1840 but during the twentieth century most of the sub-dividing boundaries were removed during phases of amalgamation. In the Pelynt study area, for instance, at the end of the medieval period as much as 83% of Medieval Enclosed Land was derived from cropping units. By 1840 almost half of these fields had been sub-divided. Since 1840 the extent of fields derived from cropping units has shrunk dramatically as a result of amalgamation and a large portion of the sub-divided fields have also undergone amalgamation. Today 70% of the fields originally derived from cropping units in Pelynt have been altered (Fig 41).

12 Archaeology of the four study areas

12.1 The monuments dataset

Following the deepening of HLC in the four study areas the next stage of the project involved an assessment and analysis of the archaeology recorded in each. Although hillforts were not included in the high level model building phase of the project (because Chi-Squared testing suggested they have a by-chance distribution), they were included in the analysis stage because they were obviously important features in the Iron Age landscape and are widely understood to have been social, administrative or territorial foci for contemporary settlement (e.g. Herring 1994; 2011, 34-5). As such they are likely to have had a profound, albeit possibly short-lived, influence on the settlement pattern. Similarly the settlement type courtyard house was not included in the modelling phase because of its highly localised distribution (confined to West Penwith), but courtyard houses are considered in the following analyses because they make up an integral part of the Romano-British settlement pattern in the Penwith study area.

12.1.1 All monuments

Additional attribute fields were added to the dataset to enable further analysis and interpretation of the monuments. The attribute fields were based on the definitions included in the Morph2 guidance document (RCHME 1993), which was developed to accompany the Morph database used in the early phases of the NMP. These were set out in full in Lowland Cornwall Volume 4, section 1.5, and included fields for height (m above OD), topographical location, aspect and validity.

This latter was based on the Validity field contained in the Morph 2 database and represents a measure of confidence of interpretation on a scale of 1 to 5, with the following definitions:

- 1 – Insufficient data
- 2 – Potential
- 3 – Possible
- 4 – Probable
- 5 - Certain

The validity field was used in the analysis to differentiate between those monuments whose interpretation is tentative (validity score of 1 or 2) and those which can be identified as prehistoric features with some degree of confidence (validity scores of 3-5). The aim was to provide some measure of how far the analysis might be skewed by unreliable data. It should be noted that only those monuments mapped as part of Cornwall's NMP will have been allocated a validity rating: in the validity field all other sites were assigned a rating of 0. As a result, a small number of sites in woodland (and therefore not visible on aerial photographs) for instance, or recorded from documentary evidence might well be *bona fide,* even though they have a validity rating of 0.

Further attribute fields were added for shape and size, where this was measurable.

12.2 Enclosures

The most numerous sites are the enclosures, with 305 in the dataset. Their distribution across the four study areas is notably uneven, with 145 (almost half the total number) in Probus, 105 in Penwith, 33 in Poundstock and only 22 in Pelynt. The majority are recorded as cropmarks, so to some extent this distribution pattern is likely to be influenced by the geology and soils in each area. It is perhaps slightly surprising that so few enclosures are recorded from the Pelynt study area. Here much of the area is covered by Denbigh 2 soils overlying slate, siltstone and sandstone. Although this combination is ranked in the medium probability zone of the geology/soils model, one might have expected more enclosures here than in Poundstock, especially as there have been a number of reconnaissance flights in the area. The apparent lack of enclosures may be because of the area’s natural topography, dominated as it is by incised valleys and long ridges of high ground.

Almost 60% of the enclosures are recorded as cropmarks, but the percentage varies from area to area: for instance 69% of the Probus enclosures but only 42% of those in Penwith are cropmarks. There are also differences between the form of remains between the high validity and other enclosures. The ratio of high validity and other enclosures is almost exactly 50:50 (152 and 153 respectively). Over the four study areas 79% of the high validity enclosures are recorded as cropmarks. By contrast only 37% of the other enclosures are cropmarks. To some extent this is because most cropmark enclosures (as well as those with above ground remains) were mapped as part of Cornwall’s NMP and therefore have been assigned a validity rating, whereas a high proportion of the enclosures with a validity 0 rating are recorded from documentary evidence and have no visible remains. In total almost a quarter of the enclosures are recorded from documentary evidence and there is a particular concentration of these in the Penwith study area (36% of the Penwith enclosures), perhaps reflecting the high level of early antiquarian work carried out there, and the relatively late destruction of sites by agriculture, compared, for example, with those in Probus. Across all four study areas only 17% of the enclosures have above ground extant remains.

Evidence	High valid enclosures	Other enclosures	Total
Cropmark	120	57	177
Extant	29	22	51
Documentary	3	68	71
Site of	0	5	5
Geophysical	0	1	1
Total	**152**	**153**	**305**

Table 55. Evidence for the enclosures across all four study areas.

The form of construction can be determined for 200 of the enclosures. More than half (54%) appear to be enclosed by a ditch alone, 27% by a bank alone and 19% by bank and ditch. However, there is a tendency in Cornwall for ditches to produce cropmarks more readily and more clearly than banks, so it might be the case that some of the ditched enclosures do have an accompanying bank which is not visible as a cropmark. A good example is Penhale Round, Fraddon. Penhale Round was first identified from aerial photographs, on which it appears as a double-ditched oval enclosure with no trace of a bank. However, excavation of the site revealed a substantial, stone-revetted enclosing bank (Nowakowski 1998). Nonetheless it should not be automatically assumed that all ditched enclosures will be bounded by a bank as well as a ditch; the open-ended enclosure at Tremough, Penryn (Gossip and Jones 2007) serves as an example of a simple, ditched enclosure with no trace of a bank.

In terms of form, however, there are differences between the four study areas. Probus has the highest percentage of ditched enclosures (68%). By contrast only 32% of the Penwith enclosures are bounded by a ditch alone. Here the majority are enclosed by a bank. This is true also of the form of construction of field boundaries in Penwith. Penwith is the only study area where a substantial part is underlain by granite. This naturally leads to a higher amount of rock at surface and therefore a correspondingly higher proportion of features originally built using stone, which probably explains this contrast with the other three study areas.

More than 70% of the enclosures are located on hill slopes, with only 10% on hill tops and a similar percentage on ridges (Chart 3). The remaining 10% are on plateaux, promontories or cliff tops.

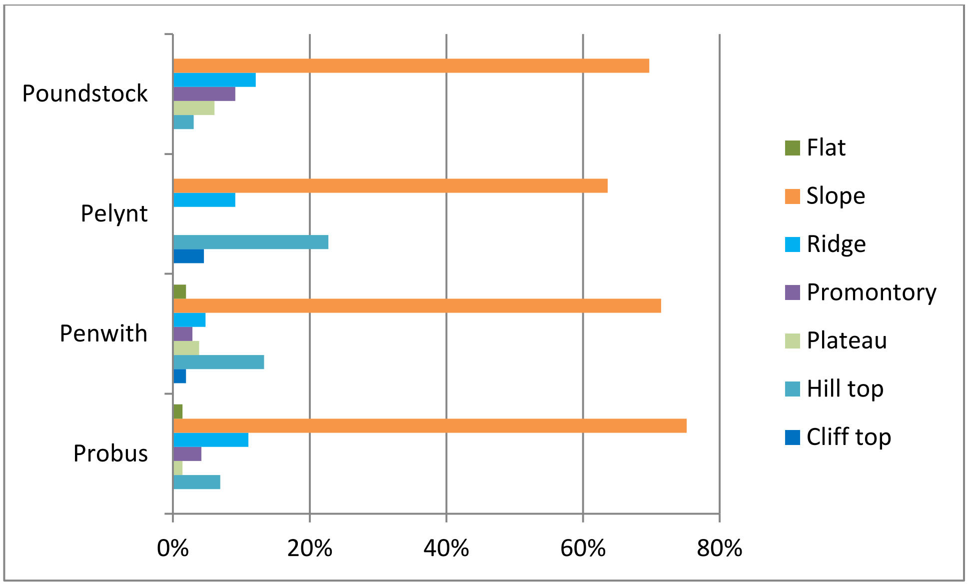

Chart 3. Topographic location of enclosures in each study area.

Similarly the enclosures are situated predominantly on the middle ground in terms of topography. Across the Lowland Cornwall project area heights OD range from just above sea level to 220m at Fraddon, St Enoder, on the fringe of the Hensbarrow uplands. Half of the enclosures are located on land lying between the 70m and 105m contours, with only eight located below the 35m contour and 10 above the 145m contour (Chart 4). Again, however, there are differences between the four study areas. Whilst there is a very clear pattern for the enclosures to be situated between the 70m and 145m contours in all four study areas, 72% of those in Probus lie between the 70m and 105m contours whereas in Penwith only 30% occupy this zone: 47% of the Penwith enclosures are on land above the 105m contour as opposed to only 11% of those in Probus. In Pelynt and Poundstock the proportions of enclosures situated between the 70m and 105m contours and above the 105m contour are roughly equal.

There are also differences between the study areas with regard to favoured aspects in the landscape (Chart 5). The majority of the Probus enclosures face westerly aspects (west, southwest or northwest), with very few facing all aspects. In the Penwith study area a majority of enclosures face southerly or easterly aspects, with very few facing west; there is no obvious preferred aspect for the Pelynt enclosures other than an avoidance of northerly aspects, whilst the majority of the Poundstock enclosures are facing northerly aspects, with very few facing south. In fact, it is a marked feature that the siting of enclosures seems to follow the general lie of the land. This is clearest in Penwith, where the natural topography slopes south and southeast towards Mount's Bay, although it is possible that, given the importance of trade, the enclosures here are sited to take advantage of sea views.

For the Probus, Penwith and Pelynt study areas this contrasts with the location of early medieval settlements. Invariably the majority of medieval settlements are situated in lower-lying land than the enclosures, with a marked preference for southerly aspects. In the Poundstock study area, however, the majority of early medieval settlements are located in higher ground than the enclosures, and on land facing easterly aspects. Overall, there is a clear trend for the early medieval settlements to favour lower ground than the enclosures – 79% of the enclosures occupy land above the 70m contour, whereas only 63% of early medieval settlements are situated in this zone.

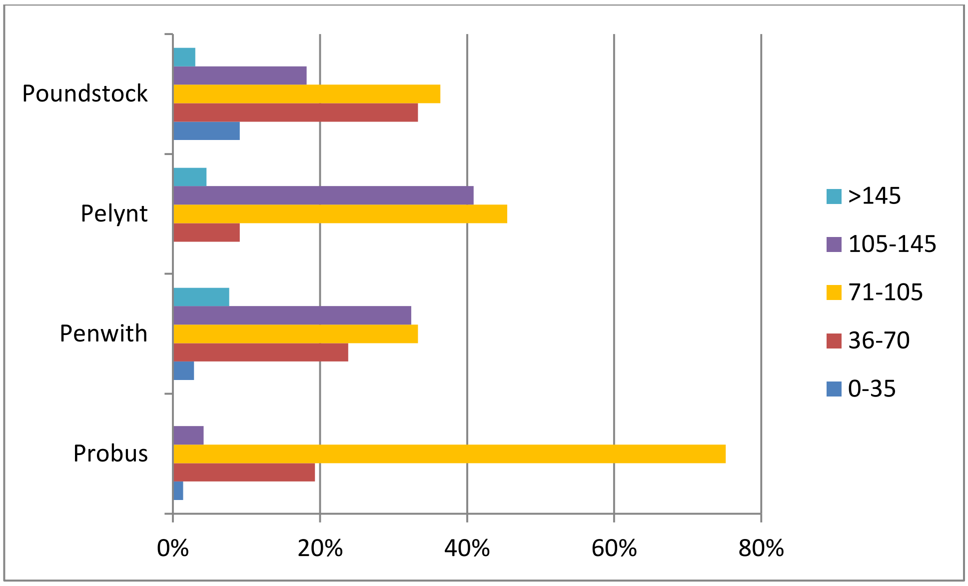

Chart 4. Height OD of the enclosures in each study area.

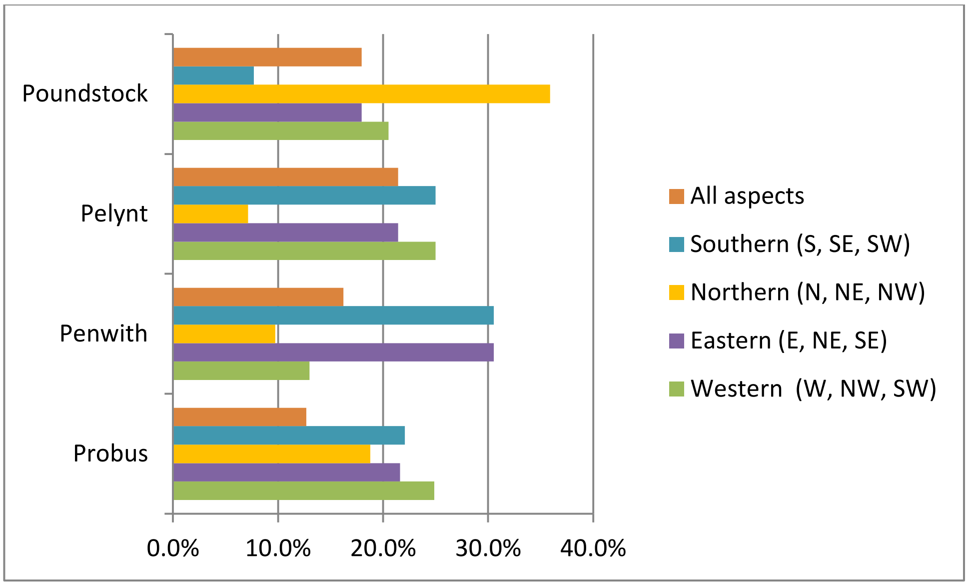

Chart 5. Aspects faced by the enclosures in each study area.

The size of the enclosed area could be measured in 187 of the enclosures (obviously these include none of the validity 0 enclosures). Of these only 10% covered an area greater than 0.5ha and only three enclosed an area greater than 1ha (excluding the outer enclosed area of multivallate enclosures). Almost 70% of the enclosures do not exceed 0.25ha in area and as many as one third of the enclosures cover an area smaller than 0.01ha (Chart 6). These proportions are similar for both the high validity enclosures and those with a low validity rating. There are some slight differences between the four study areas, the most notable being that the enclosures in Penwith are generally smaller than elsewhere – almost half the enclosures here are smaller than 0.01ha and none encloses an area greater than 0.5ha.

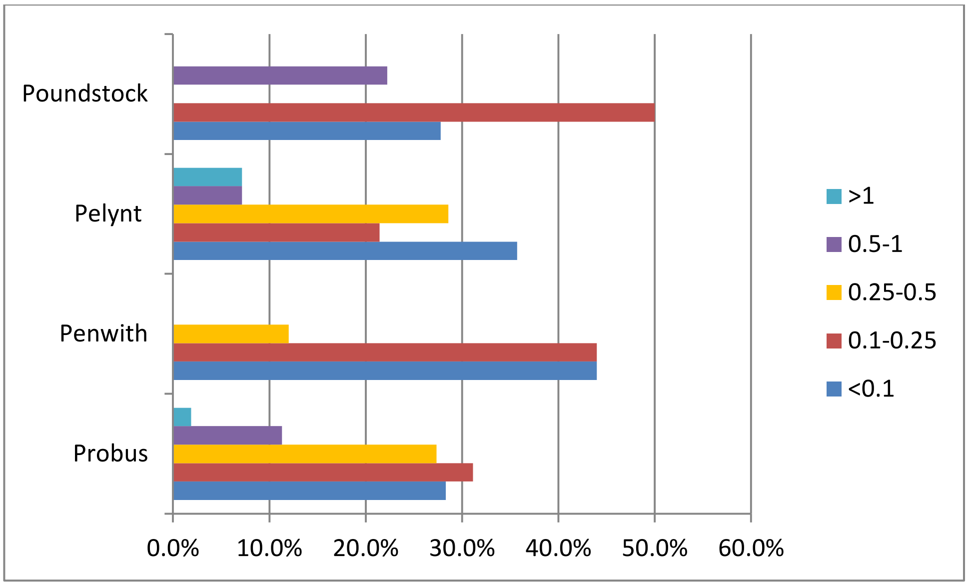

Chart 6. Size of the enclosures in each study area.

The shape of these 187 enclosures could also be defined, and slightly more than half (55%) were classed as curvilinear in form, with a roughly equal division of the others between rectilinear and mixed (23% and 22% respectively). There were some differences between the high validity and other enclosures, most notably that the percentage of low/0 validity enclosures classed as curvilinear was much higher than that of those with a high validity rating (75% as opposed to 46%).

The great majority of the enclosures are simple univallate types but 13% of the total sample can be described as more complex. These are enclosures that either have more than one enclosing ditch and/or bank and those which have a secondary appended enclosure or 'annex'. The largest group are double-ditched enclosures – those with two or more close-spaced ditches and/or banks. These are probably best considered as variants of the univallate enclosures in that they enclose a single, defined space but with two or more ditches rather than one. They differ significantly from the multivallate enclosures with wide-spaced ditches, where the outer enclosure covers at least twice the area of the inner enclosure, creating an extensive intervallate space.

A sample of typical Lowland Cornwall enclosures is shown in Fig 42. For a more detailed analysis of the enclosures the reader is referred to Lowland Cornwall Volume 4 (sections 3–6).

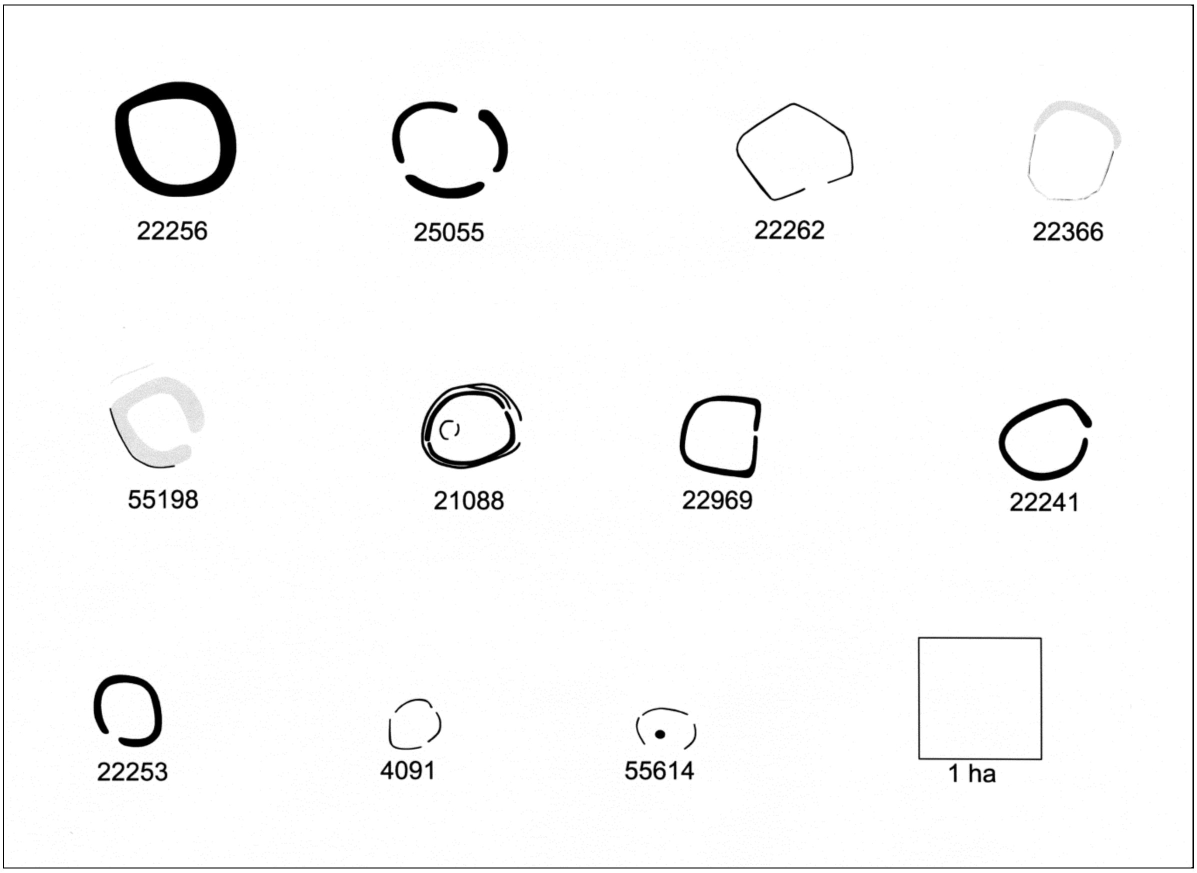

Fig 42. A sample of typical enclosures from lowland Cornwall, including one double-ditched enclosure (21088). Ditches are shown as black lines; banks in grey. North is towards the top.

The assumption has been made throughout the Lowland Cornwall project that these enclosures are settlements dating to the Iron Age or Romano-British period, based on the fact that enclosures are a characteristic settlement type from that date in Cornwall and elsewhere. However, one of the Probus enclosures, at Killigrew, St Erme, has been shown by excavation to be a dedicated metalworking site rather than a settlement (Cole and Nowakowski forthcoming), and given the results from excavations elsewhere (e.g. Lawson-Jones and Kirkham 2009-10; Jones forthcoming), it is likely that there will be other specialised types of enclosure whose function was not habitation. The initial phase at Trethurgy Round, for instance, was interpreted as a stock pound (Quinnell 2004, 214). Nonetheless, even if some of the enclosures are not settlements themselves it seems reasonable to assume that they are indicative of settlement nearby, and so can be understood to accurately represent the zone of settlement and farming.

12.3 Field systems

Across the four study areas there are records for 66 prehistoric or Romano-British field systems or field boundaries – significantly fewer records than there are for enclosures or barrows. In addition there are 32 records for undated field systems or boundaries which could potentially be prehistoric or Romano-British in origin. Within lowland Cornwall the distribution of the fields is uneven: 26 prehistoric/Romano-British and 24 undated fields are in the Probus study area; 34 prehistoric/Romano-British fields are in Penwith; two prehistoric/Romano-British and eight undated fields are in Pelynt and four prehistoric/Romano-British fields are recorded in Poundstock. All but five of the prehistoric/Romano-British field systems/boundaries have a high validity rating, and the same is true for all the undated field components.

Two thirds of the prehistoric/Romano-British fields are recorded as cropmarks, as are all the undated fields. The distribution of extant field systems is not even and those with surviving above-ground remains are largely confined to the Penwith study area. The most likely reason for the better survival of field systems in Penwith is that outlined for the high number of enclosures bounded by a bank; namely a higher proportion of features originally built using stone, which was more readily available there than elsewhere.

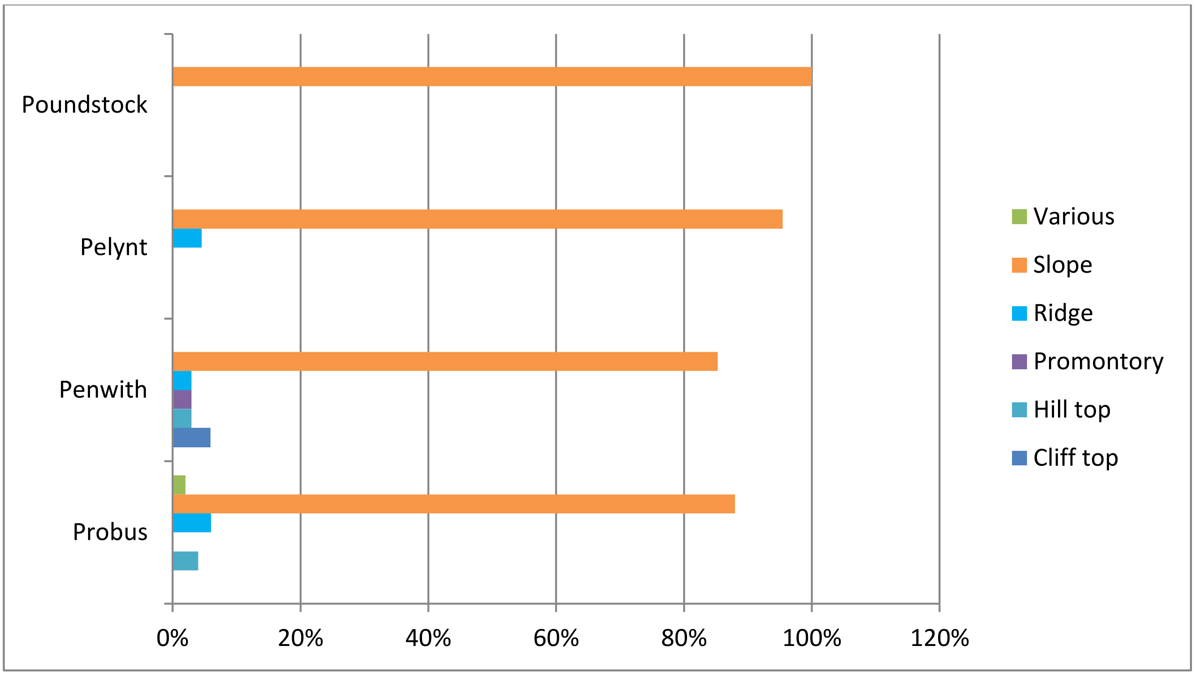

Chart 7. Topographic location of the fields in each study area.

Like the enclosures, the field systems are predominantly on hill slopes (Chart 7). This is the case both for the prehistoric/Romano-British fields, 59 (89%) of which are located on slopes, and for the undated fields of which 27 (84%) are on slopes. Similarly the fields are mostly situated in the middle ground, with more than half lying between the 70m and 105m contours (Chart 8). This is an almost exact replica of the location of the enclosures, which is to be expected given that most of the prehistoric/Romano-British fields are in close proximity to enclosures and are thus possibly associated. This is less clear for the undated fields, only 40% of which are in proximity to enclosures. Additionally there are differences in the topographical locations of dated and undated fields, with more of the latter in land above the 100m contour.

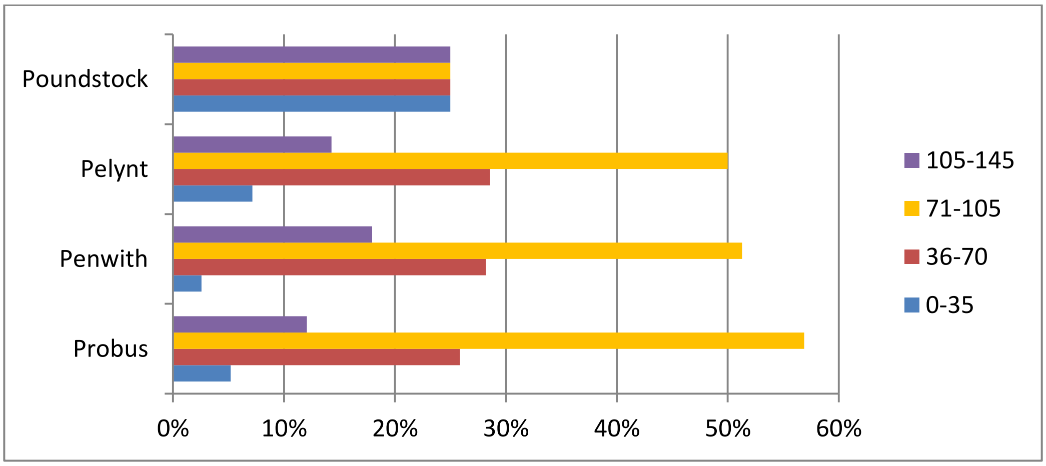

Chart 8. Height OD of land occupied by the field systems in each study area.

There are also differences between the favoured aspects for the prehistoric/Romano-British and undated fields. The dated fields mostly face southerly (30) or easterly aspects (25), whilst many undated fields face northerly (14) or westerly (10).

The field shapes are predominantly rectilinear - 73% of prehistoric/Romano-British and 66% of undated fields. Fields defined by a combination of straight and curving boundaries are the second most commonly occurring forms. Only four field systems were classed as curvilinear.

There are differences between the four areas when the construction of the prehistoric/Romano-British field boundaries is considered. Almost 90% of the Penwith fields are recorded as either extant or cropmark banks (including stony banks) whilst only four of those in the Probus study area are recorded as banks and none from either Pelynt or Poundstock. The great majority of boundaries in these study areas are formed by ditches, with only five comprising ditches and banks. The forms of the undated field boundaries are similar to this, with 29 formed by a ditch, two by a bank and one by a ditch and bank. However, it should be borne in mind that Cornish hedges – substantial structures consisting of wide stone and earth banks – when removed leave a highly distinctive double-ditched cropmark with often no hint of a central bank. It may therefore be the case that the prehistoric field boundaries appearing as ditched cropmarks may well have had accompanying banks.

Generally speaking the field systems are incomplete and fragmentary in nature, so much so that it was difficult to obtain measurements for typical field size in any of the study areas. The most coherent systems were recorded from Penwith, but even here measurements could only be made in a few instances (Fig 43). Here the average dimensions for the fields were 45m x 32m, with an average area of 0.16ha. The fields in Pelynt appear to be somewhat larger than this, at 47m x 43 and covering 0.23ha. By contrast the fields in Poundstock averaged 113m x 64 (0.34ha) and those in Probus 109m x 64m (0.67ha).

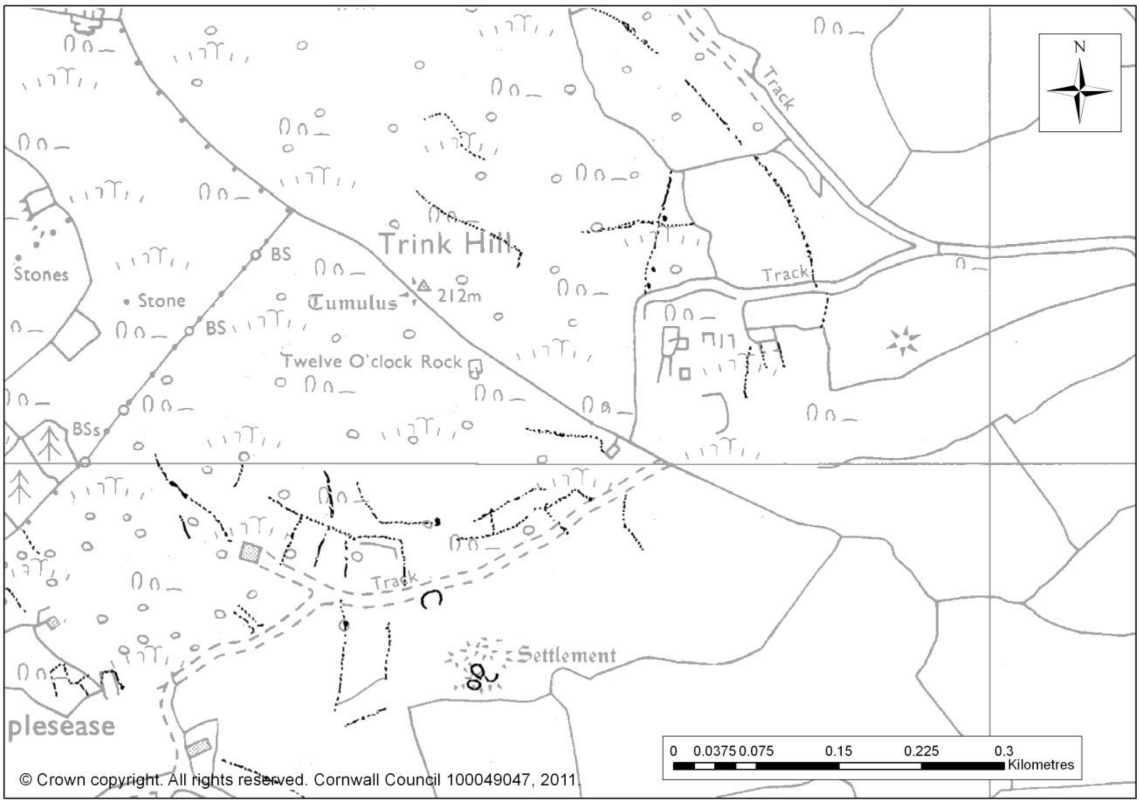

Fig 43. The fragmentary remains of a prehistoric field system at Trink Hill, Lelant. The boundaries are formed by extant stony banks.

The apparent fragmentary nature of the field systems over much of lowland Cornwall strongly suggests that we are not seeing their complete extent and it is likely that only the major boundaries produce clear cropmarks and that sub-dividing boundaries are not visible.

It might be expected that similar reorganisations of the farming system and field layout to those evident in upland areas took place in lowland Cornwall but the fragmentary nature of the evidence makes this difficult to recognise. Certainly no curvilinear accreted systems like those on Bodmin Moor have been identified in Lowland Cornwall. In parts of the Probus study area there are hints at coaxial systems but these are not extensive enough to be able to confirm this (Fig 44). In Penwith the occurrence of smaller fields than elsewhere suggests that the characteristic brick-shaped fields surviving in the West Penwith uplands did, in fact, extend into lowland areas, but again the evidence from Lowland Cornwall is not conclusive enough to say this with any real assurance.

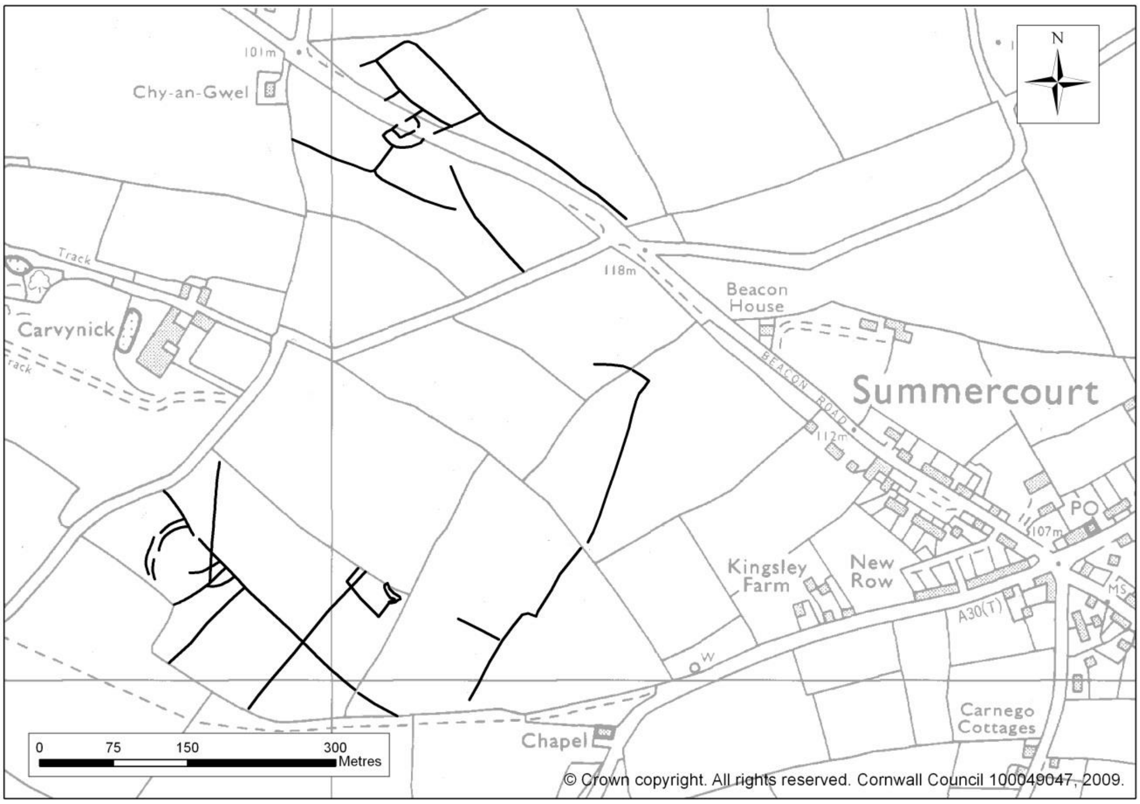

Fig 44. The fragmentary field system evidence at Summercourt, St Enoder. The boundaries are visible as cropmark ditches.

The typically fragmentary nature of the field systems is illustrated in Fig 44. There appear to be two separate groups of fields to the west of Summercourt, both possibly associated with enclosures. The relationship of the regular, rectangular fields towards the bottom left with the curvilinear, double-ditched enclosure is uncertain: they may post-date the enclosure, but it is also possible that the enclosure is appended to the long northwest-southeast boundary and is using it as its northeast side. This possibility is suggested by the fact that there is a gap in the boundary at this point – a possible entrance to the enclosure.

To the north, a less regular rectilinear field system is more clearly associated with a small enclosure. It is possible that the long south-easternmost boundary connects the two groups of fields and that the boundaries are forming part of a coaxial system aligned northwest-southeast, with some boundaries fossilised in the present day field pattern. Alternatively, it could be argued that the present day field pattern is derived from medieval strip fields and that the entire group of fields in the lower left of the illustration could be medieval or post medieval in date. Nevertheless, the upper portion of the long south-easternmost boundary runs contrary to the alignment of the present day field pattern, suggesting that all the cropmark boundaries are prehistoric in origin.

12.4 The settlement and farming landscape

A notable feature of the enclosures in lowland Cornwall is that their distribution is not even throughout the landscape. Some are sited in apparent isolation, in other cases two or more enclosures are situated in close proximity, and in some places there are dense concentrations of enclosures and other associated features. The distribution of enclosures, hillforts, roundhouses, other settlement features and field systems was mapped using polygons in each of the study areas. In total 186 'settlement polygons' were created for features dated as Bronze Age, Iron Age, Prehistoric or Romano-British, and a further 55 were created for undated features considered to be potentially of prehistoric date, giving a total of 241 polygons.

The polygons were drawn using subjective judgement and this included an element of postulating the likely extents of groups of features. The boundaries of the polygons were not defined tightly around the visible archaeology, but made allowance for the possibility that additional features do (or did) exist which are not visible either above ground or as cropmarks. Examples are shown in Figs 45 and 46.

The number of polygons varies considerably between each study area, ranging from 22 in Poundstock to 109 in Probus (Table 56). The average size of the polygons is 5.3ha and again the average polygon size varies from area to area, from 3.4ha in Poundstock to 8.4ha in Probus (the average in Pelynt is 5.5 – close to the overall average). The vast majority (83%) are 10ha or less in size and 44% cover between 1ha and 5ha. There are differences between the study areas, most notably in Probus, where there are 25 polygons greater than 10ha, as opposed to 10 in Penwith, five in Pelynt and only one in Poundstock. There are no polygons greater than 20ha in Penwith, one each in Pelynt and Poundstock and 10 in Probus.

Area (sq km)	No of polygons	Smallest (ha)	Largest (ha)	Average size (ha)
Probus	109	0.08	109.6	8.4
Penwith	73	0.16	15.6	3.9
Pelynt	37	0.15	36.4	5.5
Poundstock	22	0.5	22.2	3.4
Total	**241**			**5.3**

Table 56. Number and size range of the settlement polygons in each study area.

The most frequently occurring site types within the polygons are the enclosures: 149 (80%) of the dated polygons and 188 (78%) of all the polygons contain at least one enclosure. The polygons can be categorised on the basis of the range of site types they contain. Table 57 sets out these categories on a broad level. 'Other' includes polygons containing roundhouses, roundhouses plus other features, hillforts, hillforts and other features, and courtyard house settlements.

Site types	Probus	Penwith	Pelynt	Poundstock	Total
1 enclosure only	27 (25%)	27 (37%)	12 (32%)	11 (50%)	77 (32%)
>1 enclosure	13 (12%)	1 (1%)	0	2 (9%)	16 (7%)
1 enclosure + other features	23 (21%)	8 (11%)	11 (30%)	6 (27%)	48 (20%)
>1 enclosure + other features	29 (27%)	13 (18%)	1 (3%)	3 (14%)	46 (19%)
Field system only	12 (11%)	20 (27%)	8 (22%)	0	40 (16%)

Other	5 (5%)	4 (5%)	5 (14%)	0	14 (6%)
Total	**109**	**73**	**37**	**22**	**241**

Table 57. Analysis of the range of site types within the settlement polygons. Percentages refer to totals in the bottom row of the table.

It can be seen from this that the most frequently occurring polygons are those containing a single enclosure with no associated features. However, when the polygons containing a single enclosure plus other features and those containing more than one enclosure plus associated features are taken together they total 94 polygons, or 39% of the total number of polygons. So it is more accurate to say that the enclosures are more often recorded with other features than as solitary sites in the landscape, although such sites are not uncommon.

Isolated enclosures are most likely to be found in the Poundstock study area and least likely in Probus. Polygons containing more than one enclosure, with or without associated features, are much more frequent in the Probus study area (52 in total) than any of the others. By contrast in the Pelynt study area only one polygon contains more than one enclosure.

Of the features accompanying enclosures, field boundaries and field systems are by far the commonest. Other features include hillforts, roundhouses, ditches, pits, trackways and various combinations of these. The occurrence of these other features alongside enclosures is summarised in Table 58.

Features	Total
Field boundaries/systems	67
Field boundaries/systems and pits	4
Field boundaries/systems and trackways	3
Field boundaries/systems, trackways and pits	1
Roundhouses and field boundaries	1
Roundhouses field boundaries and pits	1
Roundhouses and trackway	1
Roundhouses and ditches	2
Hillfort, roundhouses and field system	1
Hillfort and pits	1
Hillfort and trackway	1
Hillfort	1
Trackway	3
Ditches	3
Ditches and pits	2
Pits	2
Total	**94**

Table 58. The occurrence of other features alongside enclosures.

In the area around Castallack, Paul, there are a number of sites which illustrate the range and variety of settlement polygons in lowland Cornwall (Fig 45). The northernmost contains a single cropmark enclosure with no visible associated features. In many respects this is typical of the lowland Cornwall enclosures: it is curvilinear, covers an area of 0.19ha, and is situated on sloping ground between the 105m and 110m contours. The enclosure is bounded by a single ditch with no sign of an enclosing bank.

Fig 45. Prehistoric and uncertain date settlement polygons at Castallack Carn, Paul in the Penwith study area.

In the west are three fragmented field systems, all with extant low stony banks as boundaries. As far as they can be accurately measured the fields are typically 35m x 25m.

The settlement polygon on Castallack Carn is the largest in the Penwith study area, covering 15.6ha. In the northeast part of the polygon is a probable courtyard house settlement visible as a cropmark bank. This takes the form of a figure-of-eight enclosure with what appears to be a smaller enclosure appended to its southeast side, and a cropmark roundhouse to its immediate south. It is possible that this represents two appended enclosures and a roundhouse but a courtyard house settlement seems a more likely interpretation. To the southwest of these features is an enclosure covering 0.09ha, bounded by a low bank.

To the southeast and east are the remains of prehistoric/Romano-British fields. In the SMR these are listed under two separate records, but in reality they may both be part of a single formerly more extensive field system. The fields are bounded by low stony banks and typical dimensions are 30m x 18m. The extant remains of three stone-built roundhouses are contained within the northernmost of the two field systems.

The fragmentary nature of visible prehistoric/Romano-British remains in lowland Cornwall is well illustrated by the fields at Castallack, where it is easy to envisage the surviving boundaries being part of a formerly more extensive field system. Even the many features forming the largest settlement polygon, at Trenithan Bennett, Probus, do not appear to give a complete picture of the settlement area (Fig 46). Here there are nine enclosures of various size and shape. The most interesting is that towards the southeast: this encloses 0.5ha, has a southeast-facing entrance and traces of a second enclosing ditch. It appears to have a small enclosure appended to its southern side and there are several internal features including a probable oval roundhouse, suggesting a

Romano-British date. Also of note because of its notably D-shaped form is the northernmost enclosure which covers 0.3ha.

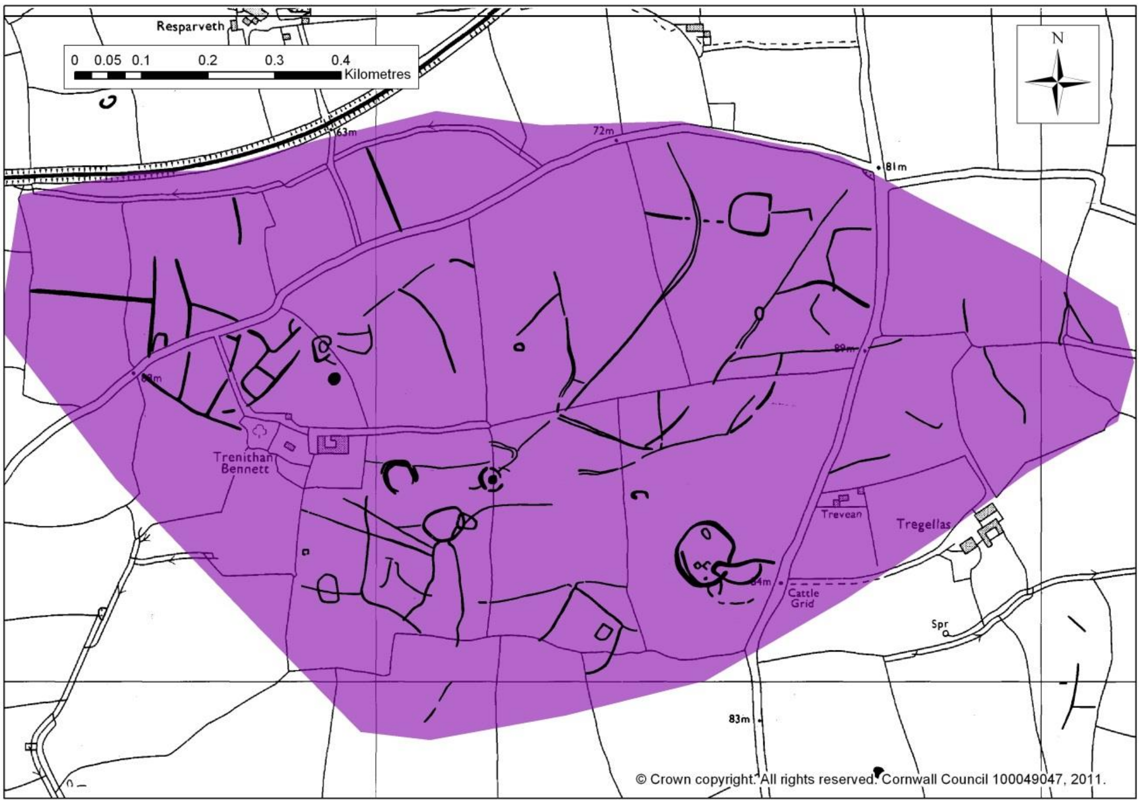

Fig 46. The settlement polygon at Trenithan Bennett, Probus.

In addition to the enclosures there are numerous fragmentary linear features, some of which are interpreted as field boundaries or trackways. Some may indeed be the surviving remnants of formerly more extensive field systems. The most coherent 'system' is that in the westernmost part of the polygon. This field system was visible on 1946 RAF aerial photographs as a series of low earthwork banks. There are two elements to it: larger fields in the west, typically measuring 148m x 63m, and smaller fields in the east, the best defined of which measures 35m square. All the other features in the Trenithan Bennett polygon are recorded as cropmark ditches. One notable feature is the centrally-located small circular enclosure with an internal pit. This feature is interpreted as a round barrow. The barrow, and those features in its close proximity, is situated on a hill top at 95m OD. Elsewhere the land slopes away to the north, south, northeast and southeast.

Clearly not all the Trenithan Bennett settlement features are contemporary with one another, but this complex of sites does demonstrate that in favourable locations in lowland Cornwall there was considerable density and continuity of occupation during the late prehistoric and Romano-British period.

This does leave the question of how to interpret the 77 enclosures visible as isolated features in the landscape, with no other enclosures in proximity and apparently with no possibly associated features present. It might be that they are isolated settlements with no associated fields. Alternatively some of these enclosures were not settlements but fulfilled some other function. It is equally possible, however, that at many of these locations there are below-ground associated features which are simply not visible on aerial photographs.

12.5 Barrows

In total 229 barrows are recorded in the Lowland Cornwall study areas. Only 97 were assigned a high validity rating, the remaining 132 having a score of 2 or less. The majority of these (65) are recorded in the SMR either from documentary evidence or as 'site of'. Ten barrows recorded as cropmarks and 36 as extant sites were not mapped during Cornwall's NMP (presumably the remains were not convincing in the view of the photo interpreters), and a further 21 were mapped but were awarded a low rating. The most populous study area was Probus, with 84 barrows, whilst the other three contain between 46 and 50. Poundstock is the only study area in which high validity barrows outnumber the other examples (26:23), whereas by contrast only 28% of the Penwith barrows have a high validity score.

Validity	Probus	Penwith	Pelynt	Poundstock	Total
High	35 (42%)	13 (28%)	23 (46%)	26 (53%)	**97 (42%)**
Low/0	49 (58%)	33 (62%)	27 (54%)	23 (47%)	**132 (58%)**
Total	**84**	**46**	**50**	**49**	**229**

Table 59. Numbers of valid and low validity barrows in the four study areas.

Overall, almost half the barrows are extant earthworks with roughly equal proportions of cropmark and documentary examples. The proportions vary from study area to study area, however, with, for example, a much higher percentage of cropmark barrows in Poundstock than in the other three areas, and a far higher percentage of barrows recorded from documentary evidence in Penwith (Table 60).

Form	Probus	Penwith	Pelynt	Poundstock	Total
Cropmark	14 (17%)	6 (13%)	11 (22%)	18 (37%)	**49 (21%)**
Extant	41 (49%)	16 (35%)	29 (58%)	25 (51%)	**111 (49%)**
Documentary	22 (26%)	22 (48%)	5 (10%)	4 (8%)	**53 (23%)**
Site of	7 (8%)	2 (4%)	5 (10%)	2 (4%)	**16 (7%)**
Total	**84**	**46**	**50**	**49**	**229**

Table 60. Form of the barrows in each study area. Percentage figures refer to the totals in the bottom row.

The majority of barrows occupy land between the 70m and 145m contours, and this is the case both for those with high or low/0 validity (Chart 9). However, there is a distinct trend for the high validity barrows to be sited on higher ground: 65% occupy land above the 105m contour as opposed to 40% of low/0 validity barrows.

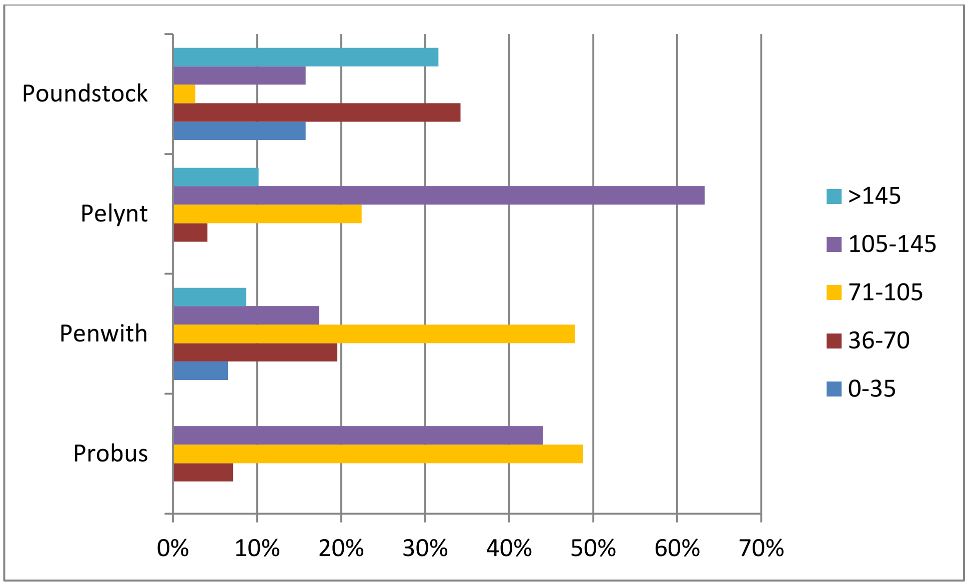

Chart 9. Height OD occupied by the barrows in each study area.

The favoured location in the landscape for the barrows is on hill slopes, with 42% of all barrows sited there. Considerable numbers are located on ridges and hill tops (25% and 21% respectively). The location of high validity barrows and those with low/0 validity scores are roughly similar, the biggest differences being that 31% of high validity barrows are situated on ridges as opposed to only 20% of the others, and that a higher proportion of low/0 validity barrows are located on hill slopes. There are also differences between the study areas: more than half the barrows in the Penwith study areas are located on slopes – a higher proportion than anywhere else, and 50% of high validity barrows in Poundstock are on hill tops – again a much higher percentage than the other study areas (Chart 10).

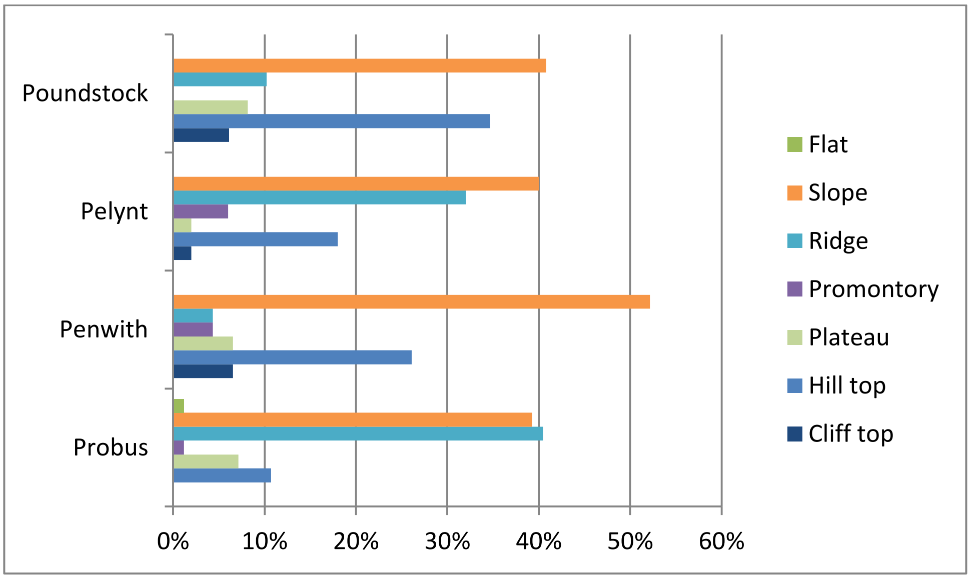

Chart 10. Topographical location of the barrows in each study area.

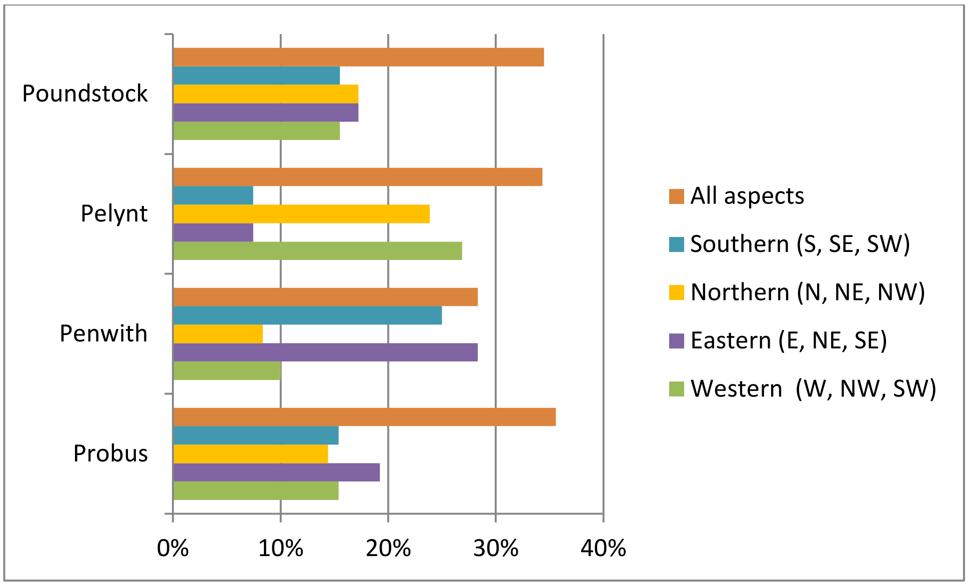

Chart 11. Aspects faced by the barrows in each study area.

Given the high numbers of barrows located on hill tops and ridges it is not surprising that almost twice as many face all aspects as any specific single one. Ninety seven barrows face all aspects whilst between 45 and 50 face southerly, westerly, northerly or easterly. The proportions vary from area to area: in Probus 56% face all aspects and in Poundstock the figure is 55%, but in Penwith and Pelynt only 22% face all aspects. In Penwith the favoured aspect is easterly and in Pelynt the favoured aspects are westerly and northerly (Chart 11).

One hundred and fourteen barrows had visible remains and were mapped during the NMP. These were recorded predominantly as mounds, whether extant or plough-levelled – 72% are mounds, 18% are visible as ring ditch cropmarks and the remaining 10% have an identifiable mound and enclosing ditch. Again, however, the proportions vary between the study areas (Table 61).

Form	Probus	Penwith	Pelynt	Poundstock	Total
Mound	30 (71%)	14 (93%)	19 (76%)	19 (59%)	**82 (72%)**
Ring ditch	9 (21%)	1 (7%)	2 (8%)	9 (28%)	**21 (18%)**
Mound and ditch	3 (8%)	0	4 (16%)	4 (13%)	**11 (10%)**
Total	**42**	**15**	**25**	**32**	**114**

Table 61. Form of construction of the barrows. Percentage figures refer to the totals in the bottom row.

All the barrows were recorded in the SMR as round barrow, bowl barrow or simply barrow, with a Bronze Age date. However, seven of the barrows are oval in shape and some might be reinterpreted as early to mid-Neolithic oval barrows. The remainder are all circular and the diameters of these were measurable in 110 cases. The predominant size range is between 11m and 20m, 82% of the barrows being between 11m and 25m in diameter (Chart 12). Four barrows measure more than 30m in diameter and nine are less than 10m.

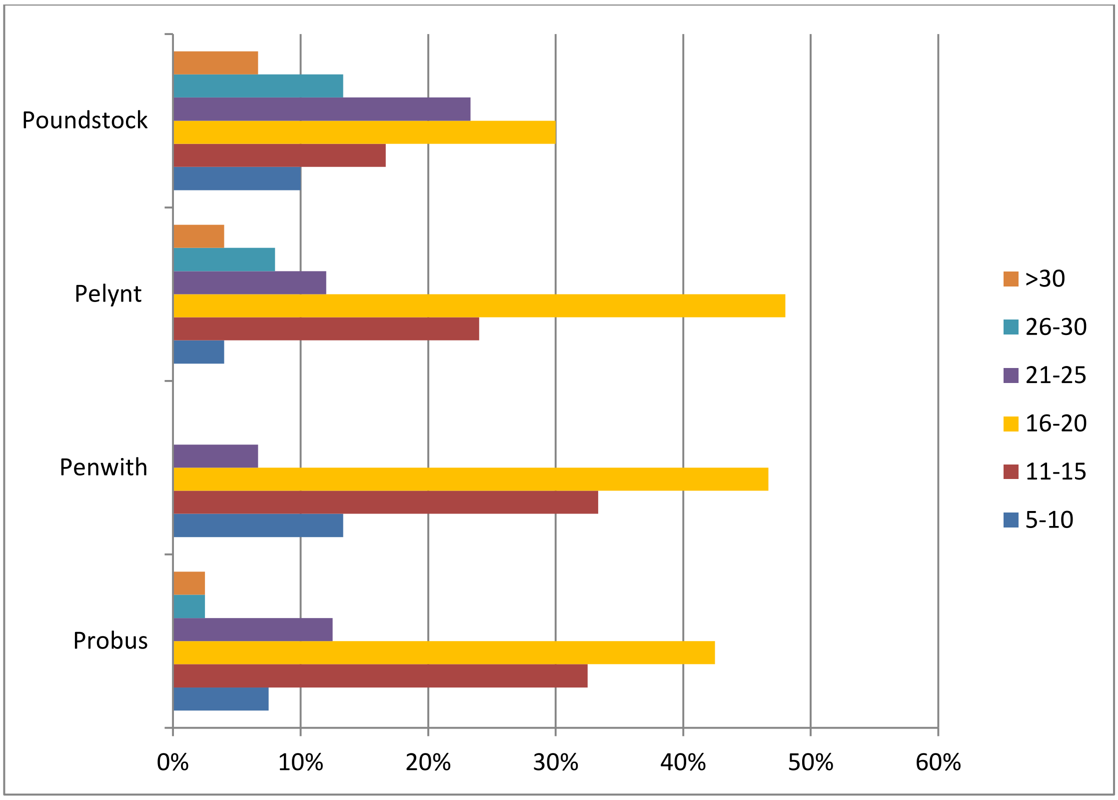

Chart 12. Measured diameters of the barrows in each study area.

In Penwith the barrows are loosely distributed throughout the study area, but elsewhere there are notable foci where there are clusters of barrows. In Probus there is a dense cluster on and around the high ground at Newlyn Downs, in Pelynt there are clusters in the southeast and north, and in Poundstock there are three major concentrations: in the southwest, southeast and north. In places two barrows are situated in close proximity to each other and there are 19 groups of three or more barrows which can be regarded as cemeteries. Elsewhere 116 barrows are located singly, apparently in isolation. The distribution pattern in Penwith differs from the other three study areas in that there is only one cemetery – around the Merry Maidens stone circle in St Buryan – and this is a scattered group of six barrows. In the Probus study area there are seven cemeteries around Newlyn Downs, in Pelynt there are five and in Poundstock six. In eight of the cemeteries the barrows are arranged in a dispersed linear alignment (Fig 47); 10 cemeteries are tightly defined, with the barrows in a cluster, and the remaining one can be described as loosely defined or 'dispersed'.

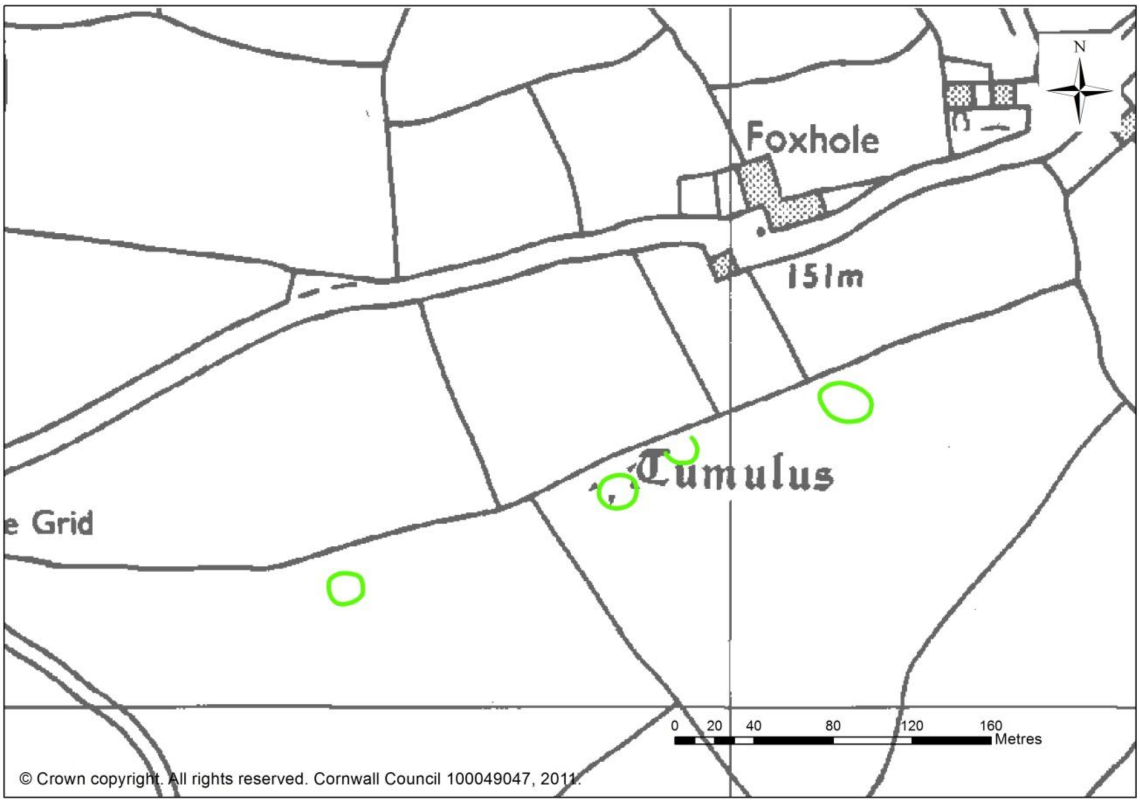

Fig 47. An extract from the NMP mapping showing a dispersed linear barrow cemetery consisting of four barrows at Foxhole in the Poundstock study area.

12.6 Conclusions

Enclosures were the most numerous site type in the dataset with records for 305, half of which had high validity ratings. Sixty percent of the enclosures were recorded as cropmarks and more were recorded from documentary evidence than as extant monuments. This was particularly the case in the Penwith study area, where there was a high concentration of enclosures recorded from documentary sources.

More than half the enclosures appear to be enclosed by a ditch alone, although this figure is very likely to be misleading because in Cornwall banks generally do not form as clear cropmarks as ditches. One unusual feature of the Penwith study area was that a majority of the enclosures there were bounded by a bank, probably due to the ready availability of stone for construction purposes.

The great majority of the enclosures are located on hill slopes and most lie between the 70m and 145m contours, although there were small differences from study area to study area. There was no obvious preference for any particular aspect in the landscape: the siting of enclosures appears to correspond to the general lie of the land. This is somewhat different to the location of early medieval settlements, which tended to favour lower lying land, often facing southerly aspects (apart from in the Poundstock study area).

Almost 90% of the enclosures were simple univallate types, of which slightly more than half were curvilinear in form; roughly equal numbers of rectilinear enclosures and those with a mixture of straight and curving sides made up the remainder. There were a small number of more complex enclosures, with either more than one enclosing ditch or with an appended enclosure attached. The enclosures were predominantly small, 70% enclosed less than 0.25ha, only 10% enclosed more than 0.5ha and only three covered more than 1ha.

The enclosures are most often recorded with other features, including other enclosures, field boundaries or field systems, trackways, pits, and occasionally roundhouses and hillforts. In some locations there are dense concentrations of enclosures and associated features, demonstrating that in favourable locations there was considerable density and continuity of occupation in the prehistoric and Romano-British period. On the other hand, it was not unusual for enclosures to be recorded as solitary sites in the landscape with no visible associated features.

There are significantly fewer records for field systems than for enclosures. Two thirds are recorded as cropmarks and those with extant remains are largely confined to the Penwith study area. Again this is probably because of the availability of stone for building in Penwith: whereas almost 90% of the Penwith field boundaries are recorded as banks (including stony banks), almost all the other field boundaries are visible as ditches.

The fields are predominantly rectilinear (only four were classed as curvilinear) but in the main the field systems are very fragmented, making it difficult to describe the field shape any more precisely. For the same reason it was difficult to accurately measure field size, but it does seem that those in the Penwith study area are smaller than elsewhere. It is quite likely that only the major field boundaries produce clear cropmarks and that sub-dividing boundaries do exist but are not visible. There are hints that some of the fields in the Probus study area are on a coaxial arrangement and that the small brick-shaped fields characteristic of the West Penwith uplands did extend into lowland areas of the Penwith study area, but in neither case is the evidence extensive enough to be truly conclusive.

In total 229 barrows were included in the dataset, of which a high proportion were ascribed low or zero validity ratings. Almost half the barrows had extant remains, with roughly equal proportions recorded as cropmarks or from documentary sources. Although the favoured location for the barrows was on hill slopes, many are located on hill tops or ridges and the majority of barrows face all aspects. However, this varies from study area to study area: in Penwith for instance the majority of barrows are situated on hill slopes and the commonest aspect is easterly.

The barrows were predominantly identified as mounds (whether cropmark or extant), with only 18% recorded as ring ditches and only 10% as mounds and ditches. The predominant diameter size range was between 11m and 20m, four measured more than 30m in diameter and nine less than 10m. Apart from in the Penwith study area there are notable clusters of barrows, including 19 groupings or 'cemeteries'. These are often located on high ground in prominent positions in the landscape. Elsewhere the barrows are loosely distributed throughout the study areas, and at 116 locations barrows are recorded singly, apparently in isolation.

13 The fine grained models

A weakness identified in some of the high level models built in the first stage of the project was a lack of precision resulting from the extensive area covered by the HLC Type Farmland Medieval (section 9). It was hoped that this inherent lack of precision might be rectified to a degree by a deepening of the existing HLC, because this would involve the subdivision of Farmland Medieval into a number of less extensive Sub-Types. Assuming that some of the Sub-Types would contain significantly more or less enclosures than others, the size of the high probability zone would effectively be reduced and the precision of the model thereby increased. It was also thought likely that defining the previous HLC time-slices of Farmland C20 might strengthen the model because the high ranking of Farmland C20 probably reflects the presence of enclosures in areas that were formerly Farmland Medieval or Farmland Prehistoric, but which have been significantly altered during the latter part of the twentieth century. Models were built using the deepened HLC Types and Sub-Types as variables and also the Landuse attributes.

13.1 Models based on early medieval land use

In the Landuse attribute tables land was classed as Core, Sub-core, 'Tidal' or Marginal using the Historic Settlement dataset as a guide. Place-names with habitative elements, such as *tre* (farming estate), are indicative of an early medieval origin, whilst those with topographical elements, such as *nans* (valley) may reflect an expansion from the early medieval core settlement zone indicated by the habitative place-names (Preston-Jones and Rose 1986, 143-4).

Following the model proposed by Preston-Jones and Rose, the Core settlement zone would be seen as the area where continuity in settlement and farming is most likely to have existed from later prehistory through to medieval times. The term 'Sub-core' was used to describe land which may have been associated with early medieval settlement and therefore possibly part of the core settlement zone. The areas containing topographical place-names are likely to have formed a 'Tidal' zone, in which settlement and farming came and went in the past, as economic need or other circumstances dictated, and which became permanently settled in the later medieval period. Land not identified as any of these three types was classed as Marginal: that is where settlement would not normally be expected.

Alternatively the main area of settlement in the Iron Age and Romano-British periods may have been the 'Tidal' zone, and changing circumstances in the early medieval period led to a colonisation of the slightly lower ground on which the *trefs* are now located. Given that the prehistoric enclosures appear to be located on higher ground than early medieval settlements in the Probus, Penwith and Pelynt study areas this latter scenario may be the case.

In the event only a very small area was classed as Sub-core so in the results presented here it is assumed that Sub-core and Core are one and the same and have been grouped together as the Core zone.

Landuse zone	Probus	Penwith	Pelynt	Poundstock	Total
Core	46.2 (34%)	29.2 (31%)	24.5 (27%)	10.3 (16%)	**110.1 (29%)**
'Tidal'	49.1 (36%)	29.4 (31%)	37.9 (43%)	29.8 (45%)	**146.3 (38%)**
Marginal	40.2 (30%)	35.2 (38%)	26.7 (30%)	25.5 (39%)	**127.6 (33%)**
Total	**135.5**	**93.8**	**89.1**	**65.6**	**384**

Table 62. The extent of the three Landuse zones in each study area. Figures are in square kilometres. Percentages refer to totals in the bottom row.

The three Landuse zones are roughly evenly distributed across the four study areas, the 'Tidal' zone being the largest and the Core the smallest in extent (Table 62). However, there are differences between the study areas, most strikingly that the Core zone only covers 16% of Poundstock. This may reflect the relatively small number of settlements with Cornish place-names here (only 23, compared with 57 in Pelynt and more than 80 in both Probus and Penwith). Also of note is the fact that the Marginal zone is the largest in Penwith as opposed to the 'Tidal' zone elsewhere.

13.1.1 Enclosures and Landuse

None of the models for enclosures against Landuse zones were entirely satisfactory. When all four study areas were taken together the Core zone was ranked highest but the 'Tidal' zone captured more enclosures (it is ranked lower because it covers a larger area). In fact the performance of these two zones is almost identical: the Indicative Value (PS/PA) of the Core zone is 1.3 and that of the 'Tidal' zone 1.2. Whether the Kj parameters or Relative Gain measures are used to define the cut-off point between the high and medium probability zones, the outcome is a two-zone model with the high probability zone formed by the Core and 'Tidal' areas and the Marginal areas making up the low probability zone. The high probability zone is accurate in that it captures 83% of the enclosures but lacks precision, producing a Kvamme's Gain of 0.195 (table 63).

Landuse zone	Area (sq km)	Enclosures	PA	PS	Kj	Rel gain	Kvamme's gain
Core	110.145	117	0.287	0.384	0.193	0.097	0.252
'Tidal'	146.299	136	0.381	0.446	0.366	0.162	0.195
Marginal	127.606	52	0.332	0.170	0	0	0
Total	**384.05**	**305**					

Table 63. Results of enclosures modelled against Landuse zones.

There are considerable differences in the location of the high validity and other enclosures; with 15% more high validity enclosures located in the Core area than in the 'Tidal', but 11% more low/0 validity enclosures in the 'Tidal' area than in the Core.

Landuse zone	High validity enclosures	Other enclosures	All enclosures
Core	70 (46%)	47 (31%)	117 (38%)
'Tidal'	60 (39%)	76 (50%)	136 (45%)
Marginal	22 (15%)	30 (19%)	52 (17%)
Total	**152**	**153**	**305**

Table 64. Distribution of valid and low validity enclosures in the three Landuse zones.

This overall pattern, a two-zone model with the Core and 'Tidal' areas forming the high probability zone, is replicated in the Probus, Penwith and Pelynt study areas, although with some differences. In Probus and Pelynt the Core areas are ranked highest and the Core and 'Tidal' areas between them capture 90% of the enclosures. In Penwith, however, the 'Tidal' areas are ranked highest and the high probability zone captures only 79% of the enclosures.

In Poundstock the situation is quite different. Here the high probability zone of the model is made up of the 'Tidal' and Marginal areas, with the Core areas ranked third, capturing only 12% of the enclosures. In fact the model for the Poundstock study area suggests a virtually by chance distribution pattern with the 'Tidal' zone covering 46% of the study area and capturing 49% of the enclosures, and the Marginal zone covering 39% and capturing 39% of the enclosures.

The models for each study area were tested by using data from the other three areas. To do this a test model was created for three study areas and the number of enclosures per square kilometre captured in each Landuse zone was calculated. This model was then applied to the fourth study area and the number of enclosures per square kilometre was used to predict how many enclosures would be captured in each Landuse zone if the model was correct. The best fit was achieved when the model for Probus, Penwith and Poundstock was applied to the Pelynt study area (Table 65).

Landuse	Actual enclosures	Predicted PS	Predicted enclosures	Actual PS
Core	9	0.36	8	0.41
'Tidal'	11	0.50	11	0.50
Marginal	2	0.15	3	0.09
Total	**22**		**22**	

Table 65. Comparison of the predicted and actual PS values and predicted and actual numbers of enclosures in the Pelynt study area based on the Probus, Penwith and Poundstock model.

The prediction for the 'Tidal' zone was totally accurate and the Core zone captured one more enclosure than predicted. When the Probus study area was tested with a model combining Penwith, Pelynt and Poundstock the Core area performed better than predicted, capturing 67 enclosures rather than the 58 predicted, the 'Tidal' zone captured 63 as opposed to the 59 predicted and as a consequence the Marginal zone captured only 15 enclosures instead of the 28 predicted.

The Poundstock study area produced the worst test result. Here the Marginal zone captured 13 enclosures instead of the six predicted, at the expense of both the Core and 'Tidal' zones. Nor did the Probus, Pelynt and Poundstock model fit the Penwith study area particularly well, with the 'Tidal' and Marginal zones performing better than predicted (Table 66).

Landuse	Actual enclosures	Predicted PS	Predicted enclosures	Actual PS
Core	37	0.46	48	0.35
'Tidal'	46	0.36	38	0.44
Marginal	22	0.18	19	0.21
Total	**105**		**105**	

Table 66. Comparison of the predicted and actual PS values and predicted and actual numbers of enclosures in the Penwith study area based on the Probus, Pelynt and Poundstock model.

There are also differences between the results for high validity enclosures and those with low/0 validity scores. These are illustrated by comparison of the Indicative Values for the Core zones of each study area in Table 67 below.

Study area	Valid enclosures	Other enclosures	All enclosures
Probus	1.5	1.2	1.4
Penwith	1.5	0.8	1.1
Pelynt	1.8	1.3	1.5
Poundstock	1.1	0.4	0.8
All areas	1.6	1.1	1.3

Table 67. Indicative Values for the Core zone of Landuse models for each study area.

In each case the Indicative Values for the Core zone are higher when only the high validity enclosures are considered. In particular the Indicative Value for low/0 validity enclosures in Poundstock is just over one third that for the high validity enclosures and in Penwith the Indicative Value for low/0 validity enclosures is just over half that for the high validity enclosures. Almost one third of all the low/0 validity enclosures are recorded from documentary evidence. In many cases the evidence is based on place-name elements, which have been used here to define the Core zone, so it is perhaps surprising to find so many enclosures recorded from documentary evidence in the 'Tidal' and, especially, in the Marginal zones.

The application of these models suggests that over the four study areas as a whole the Landuse zone Marginal is the low probability zone, where the fewest number of enclosures are located, although the degree to which this is the case varies from area to area. The weakness of the models is that there is very little distinction between the Core and 'Tidal' zones in terms of probability, so they fail to shed any light on the question of whether the Core area of early medieval settlement perpetuated that of earlier periods or whether the 'Tidal' area was the main settlement zone in the prehistoric and Romano-British period.

13.1.2 Barrows and Landuse

There are similar inconsistencies inherent in the Landuse models for barrows (Table 68). Taken together over the four study areas the Marginal zone is ranked highest. The Relative Gain measures indicate that the Marginal areas should form the high probability zone of the model, even though only 49% of the barrows are located there. The Kj parameters, on the other hand, suggest that the high probability zone is formed by Marginal and Core areas. This zone captures 75% of the barrows but is not very precise, achieving a Kvamme's Gain of 0.176.

Landuse zone	Area (sq km)	Barrows	PA	PS	Kj	Rel gain	Kvamme's gain
Marginal	127.606	112	0.332	0.489	0.277	0.157	0.321
Core	110.145	60	0.287	0.262	0.315	0.132	0.176
'Tidal'	146.299	57	0.381	0.249	0.000	0.000	0.000
Total	384.05	229					

Table 68. Results of barrows modelled against Landuse zones. All study areas.

However, this pattern is only replicated in the Probus study area, and the Marginal zone is only ranked highest there and in Poundstock. In fact the rankings of the three Landuse zones are different in each of the study areas (Table 69).

Study area	Rank 1	Rank 2	Rank 3
Probus	Marginal	Core	'Tidal'
Penwith	Core	Marginal	'Tidal'
Pelynt	Core	'Tidal'	Marginal
Poundstock	Marginal	'Tidal'	Core

Table 69. Comparison of the results of the barrows against Landuse models for the four Lowland Cornwall study areas.

To some extent the outcome of the model for all barrows is skewed by the different size of the study areas and the number of barrows in each. For instance there are 84 barrows in the Probus study area but only 50 or less in each of the other three. In Probus 48 of the barrows are located in the Marginal zone – this is more than the total number of barrows in the Penwith study area.

Another factor is the large number of barrows in prominent locations on high ground, particularly around Newlyn Downs in the Probus study area and various locations in the Poundstock study area. Such locations are for the most part classed as Marginal, which explains why in the Probus and Poundstock study areas the Marginal zone equates to the high probability zone. In fact it can be suggested that the barrows fall into two categories: those in prominent locations which are mainly within the Marginal zone, and those on lower lying land which have no obvious pattern in terms of Landuse zones. This is clearest in the Penwith study area, where there is effectively a by-chance distribution, with the barrows fairly evenly distributed through the three Landuse zones. The by-chance distribution is confirmed by the extremely low Kvamme's Gains.

Landuse zone	Area (sq km)	Barrows	PA	PS	Kj	Rel gain	Kvamme's gain
Core	29.202	15	0.311	0.326	0.070	0.015	0.046
Marginal	35.224	17	0.375	0.370	0.080	0.009	0.013
'Tidal'	29.412	14	0.313	0.304	0.000	0.000	0.000
Total	93.838	46					

Table 70. Results of barrows modelled against Landuse zones. Penwith study area.

One striking aspect of the barrow dataset is the high proportion of low or zero validity sites, which outnumber the high validity barrows by more than a third. Poundstock is the only study area in which there are more high validity barrows. At the other end of the scale there are more than twice as many low/0 than high validity barrows in the Penwith study area. There are some differences in the distribution of high and low/0 validity barrows. For instance, in the Probus study area there are equal numbers of low/0 validity barrows captured in the Marginal and Core zones, whereas there are seven times more high validity barrows in the Marginal zone than there are low/0 validity barrows. In the Penwith study area the highest number of low/0 validity barrows is captured in the 'Tidal' zone yet this zone captures the lowest number of high validity barrows.

Zone	Probus			Penwith			Pelynt			Poundstock		Total	
	High	Low/0		High	Low/0		High	Low/0		High	Low/0	High	Low/0
Marginal	28	20		6	11		4	8		18	17	56	56
Core	4	20		5	10		8	11		1	1	18	42
'Tidal'	3	9		2	12		10	9		7	5	22	35
Total	**35**	**49**		**13**	**33**		**22**	**28**		**26**	**23**	**96**	**133**

Table 71. Distribution of high validity and low/0 validity barrows in each study area.

Only in the Poundstock study area are the models for high and low/0 validity barrows identical, with the Marginal areas forming the high probability zone. The corresponding models in Probus and Pelynt are only slightly different: in Probus the Marginal areas form the high probability zone for the high validity barrows whilst the high probability zone for low/0 validity barrows is made up of the Marginal and Core areas. In Pelynt the high probability zone is formed by Core and 'Tidal' areas for the high validity barrows and by Core and Marginal areas for the low/0 validity barrows. In Penwith the models are more at variance, with Marginal areas ranked highest for the high validity barrows but 'Tidal' areas highest in the low/0 validity barrows model. However, as there are so few high validity barrows in the Penwith study area it is probably wise not to read too much into this disparity.

13.2 Models based on Lowland Cornwall HLC Types and Sub-Types

The results of the modelling process are presented here in a series of tables which use the following abbreviations:

Emod	Early Modern
MD	Medieval
Mod	Modern
PM	Post-Medieval
PX	Prehistoric

Models were made for the enclosures and barrows using the deepened HLC Types and Sub-Types for all four time-slices. The models were made in the same way as the high level models, using the Kj parameter to rank each Sub-Type or Type and to define the cut-off points between the high, medium and low probability zones. However, in a number of cases the cut-off points were better defined by using the Relative Gain measures which produced greater precision. When deciding how to define the cut-off point between the high and medium probability zone, accuracy levels of 70% of sites in the high probability zone were sought, although in some cases this was not achievable.

Additional models were made for the enclosures based on combinations of Types and Sub-Types across all four time-slices. So, for instance, in the Probus study area the highest-ranked combination of Sub-Types was:

Time-slice	Sub-Type
2011	MD Altered field patterns (Amalgamated)
1880	MD derived from Cropping Units
1840	MD derived from Cropping Units
Medieval	MD derived from Cropping Units

Given the large number of possible combinations this procedure was extremely time-consuming and resulted in numerous complex GIS queries. Given the available resources it was therefore not practical to repeat the exercise with the barrows.

The models were tested in two different ways; firstly by producing a model for all four study areas for each site type and then applying this to each study area in turn to see how closely the model might fit. Secondly by producing a model for sites in three study areas and then applying this to the fourth, in the same way that the Landuse models were tested. For the enclosures a third test was carried out by taking randomly chosen ecclesiastical parishes from each study area to create two roughly equally sized areas, producing a model for each and then using the model from one to test the other.

13.2.1 Enclosures

When the 1994 HLC model was applied to the four study areas it was in the main found to be accurate: in Penwith it was similar to its county-wide performance, capturing 79% of the enclosures, and in both Probus and Pelynt it was more accurate, capturing 87% and 95% respectively. In terms of precision the model performed better in Pelynt than it did county-wide, but in Probus and Penwith it was less precise, producing Kvamme's gains of 0.112 and 0.165. By contrast the model did not perform well in the Poundstock study area. Although the model's high probability zone captured 64% of the enclosures it produced a negative Kvamme's Gain, and the medium probability zone was actually ranked highest.

It is fair to say that in each of the four study areas the Lowland Cornwall HLC Types produced better performing models than the 1994 HLC Types. In both Probus and Pelynt the high probability zones were more accurate across the four time-slices, capturing between 88% and 96% of the enclosures, and also more precise with Kvamme's Gains ranging from 0.210 to 0.261. In the Penwith study area the models were of similar accuracy to the 1994 model, the 2010, 1880 and 1840 time-slice models were more precise, but that for the medieval time-slice was less so. In Poundstock, although the models performed better than the 1994 model, capturing between 67% and 73% of enclosures in their high probability zones and producing positive Kvamme's Gains, these gains were very low, ranging from 0.050 to 0.170. In fact for the 1880 and 1840 time-slices the models in Poundstock suggested a virtually by-chance enclosure distribution: for instance in the 1840 time-slice the high probability zone captured 67% of the enclosures and covered 63% of the study area.

In all four study areas the highest-ranked HLC Type was Medieval Enclosed Land, and in Penwith Prehistoric Enclosed Land was ranked second. The predominance of Medieval Enclosed Land in the high probability zones was underlined when the models were made using Sub-Types as the variables. For example, when all four study areas were considered together the high probability zone of the 2011 time-slice model contained three Medieval Enclosed Land Sub-Types (Table 72).

HLC Sub-Types	Enclosures	PA	PS	Kj	Rel gain
MD Altered field patterns (Amalgamated)	148	0.334	0.485	0.271	0.151
MD derived from Cropping Units	31	0.080	0.102	0.318	0.173
PX Altered field patterns (Amalgamated)	17	0.013	0.056	0.372	0.215
MD Altered field patterns (Sub-Divided)	25	0.076	0.082	0.401	0.222
Total	**221**	**0.503**	**0.725**		

Table 72. High probability zone of the 2011 time-slice enclosures model. All study areas.

The high probability zone captured 72.5% of the enclosures in 50% of the project area and produced a Kvamme's Gain of 0.306. When only the high validity enclosures were modelled exactly the same result was achieved in terms of ranking of the Sub-Types, but with a slightly higher Kvamme's Gain of 0.392. These same four Sub-Types also made up the high probability zone of the 1880 time-slice model (although in a different order of rank) and were the four highest-ranked Sub-Types in the 1840 time-slice model.

When models were made for each of the four study areas there were, however, differences in the make-up of the high probability zones. Only in Probus were the high probability zones formed exclusively by Medieval Enclosed Land Sub-Types and here a map showing the distribution of enclosures (Fig 48) clearly illustrates that the enclosures are virtually confined to areas of Medieval Enclosed Land (in fact only 15 of the 145 Probus enclosures are not located in Medieval Enclosed Land).

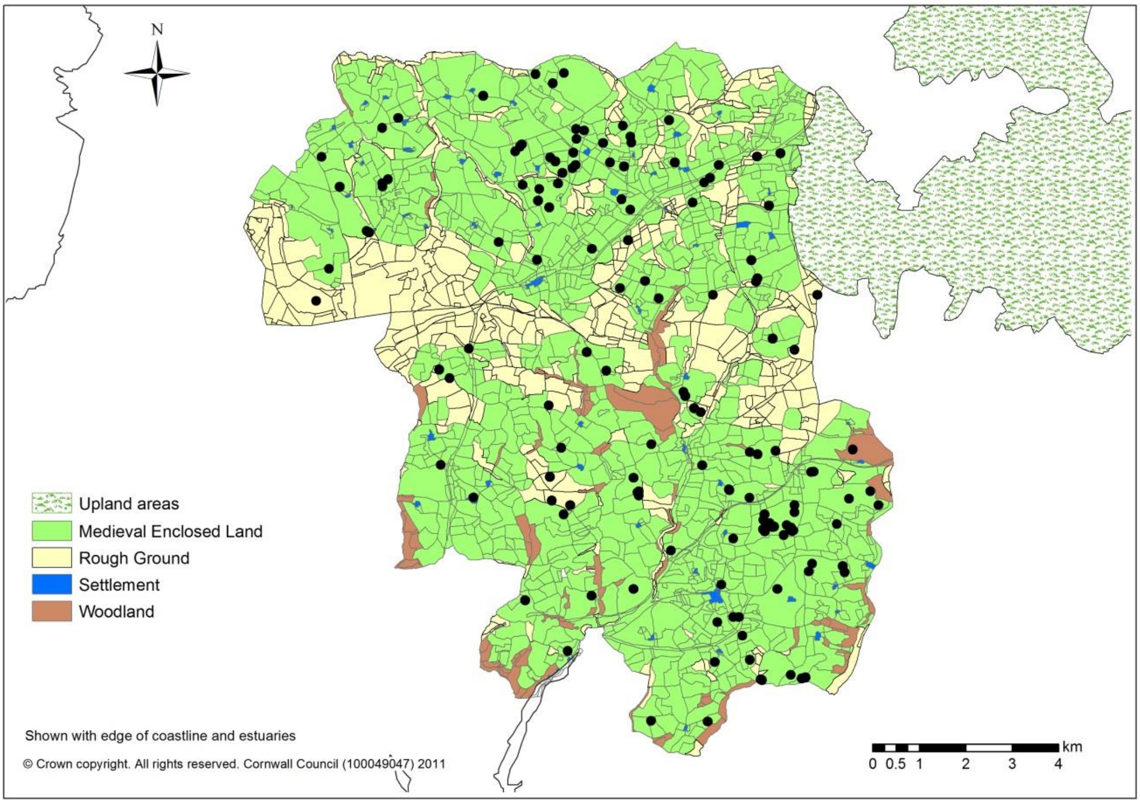

Fig 48. Distribution of enclosures in the Probus study area. Background is the medieval time-slice HLC.

Elsewhere, although the high probability zones were dominated by Medieval Enclosed Land Sub-Types, they also contained Rough Ground or more recently enclosed land Sub-Types. This was the case in all time-slices as Table 73 shows (in this case the 1880 time-slice).

Rank	Probus		Pelynt
1	MD derived from Cropping Units	1	MD Altered field patterns (Sub-Divided)
2	MD Altered field patterns (Amalgamated)	2	MD Altered field patterns (Amalgamated)
3	MD Altered field patterns (Sub-Divided)	3	MD derived from Cropping Units
4	MD Altered field patterns (Re-arranged)	4	Emod Intakes
	Penwith		**Poundstock**
1	PX Altered field patterns (Amalgamated)	1	MD Altered field patterns (Amalgamated)
2	MD Altered field patterns (Amalgamated)	2	MD peripheral fields
3	MD Altered field patterns (Sub-Divided)	3	MD Altered field patterns (Sub-Divided)
4	MD derived from Cropping Units	4	Upland Rough Ground (divided)
5	MD Altered field patterns (Re-arranged)		
6	Upland Rough Ground (divided)		
7	Valley Rough Ground (divided)		
8	MD derived from Strip Fields (Enclosed)		

Table 73. Comparison of the enclosures model high probability zones in each study area. 1880 HLC time-slice.

For the most part the models based on HLC Sub-Types produced more precise models than those based on Types, albeit with a slight decrease in accuracy. Broadly speaking the combinations of Sub-Types making up the high probability zones were consistent throughout the time-slices, allowing for changes in field patterns through time, for instance fields classified as sub-divided in the 1840 time-slice being replaced by amalgamated fields in the 2011 time-slice (see Lowland Cornwall volume 3, section 4.2.9 and fig 31). The exception to this general trend was Poundstock, where there were significant differences between the high probability zones from time-slice to time-slice.

2011 time-slice.		1880 time-slice.
MD Altered field patterns (Sub-Divided)	1	MD Altered field patterns (Amalgamated)
MD Altered field patterns (Re-arranged)	2	MD peripheral fields
PM Altered field patterns (Amalgamated)	3	MD Altered field patterns (Sub-Divided)
Deciduous woodland	4	Upland Rough Ground (divided)

1840 time-slice.		Medieval time-slice.
MD peripheral fields	1	MD peripheral fields
MD Altered field patterns (Re-arranged)	2	Coastal Rough Ground (undivided)
PM Intakes	3	MD derived from Cropping Units
MD Altered field patterns (Sub-Divided)	4	
Upland Rough Ground (divided)	5	
MD Altered field patterns (Amalgamated)	6	
Upland Rough Ground (undivided)	7	
Deciduous woodland	8	

Table 74. Sub-Types forming the high probability zones for each time-slice model for enclosures in the Poundstock study area.

Also in the Poundstock study area there are significant differences between the make-up of the high probability zones of the all enclosures models and those for high validity enclosures only. The most obvious case is in the 1880 time-slice where only one of the four Sub-Types in the high probability zone of the enclosures model is included in that of the high validity enclosures model. However, variance between the all enclosures and the high validity enclosure models is most notable in the Penwith study area where some Rough Ground and former Rough Ground Sub-Types are included in the high probability zones of the all enclosures models, but not in the high validity enclosure models. This is best illustrated by comparing the make-up of the high probability zones of models for the high validity and other enclosures, in this case for the 1840 time-slice (Table 75).

High validity enclosures		Other enclosures
PX Altered field patterns (Amalgamated)	1	MD Altered field patterns (Sub-Divided)
PX Altered field patterns (Sub-Divided)	2	Upland Rough Ground (divided)
PX field patterns	3	MD Altered field patterns (Re-arranged)
MD Altered field patterns (Sub-Divided)	4	MD derived from Cropping Units
MD derived from Strip Fields (Enclosed)	5	PX Altered field patterns (Amalgamated)
MD derived from Cropping Units	6	Emod Intakes
PX Altered field patterns (Re-arranged)	7	Hamlet

Table 75. Comparison of the high probability zones of the high and low validity enclosures models in the Penwith study area. 1840 time-slice.

There are significant differences between the two: no Sub-Type is ranked the same in both models, four Sub-Types in the high validity enclosures model are not included in the high probability zone of the other enclosures model, and Upland Rough Ground and Early Modern Intakes are included in the high probability zone of the low/0 validity enclosures, but not that of the high validity enclosures model.

In fact just over 10% of the high validity enclosures in Penwith are located in land not classed as Medieval or Prehistoric Enclosed, whereas the corresponding figure for the low/0 validity enclosures is 33%. This suggests that the interpretation of some of the low/0 validity enclosures might be questioned, particularly those recorded from documentary sources, of which there is a high proportion in Penwith.

Although the Lowland Cornwall HLC produces more precise models for enclosures than the 1994 HLC, particularly when the models are made with Sub-Types as variables, the increase in precision is not great. The highest Kvamme's Gain achieved by any of the models was 0.264, in the 1880 time-slice model for the Pelynt study area. In an attempt to create more precise models, the combinations of Sub-Types across all four time-slices (five in the case of Penwith) were modelled as variables. Not only did this approach produce more precise models, it also had the advantage of taking into account variations in the make-up of the high probability zones from time-slice to time-slice.

The starting point for construction of this type of 'regressive' model was the acknowledgement that, in broad terms, Medieval Enclosed Land (and Prehistoric Enclosed Land in Penwith) forms the high probability zone. Therefore only those polygons classed as Medieval or Prehistoric Enclosed Land during at least one time-slice were considered when defining the high probability zones of these models.

Within this overall high probability zone some Sub-Type combinations capture considerable numbers of enclosures, others capture only a single enclosure and some capture none. Thus it was possible to refine the high probability zone by identifying those combinations of Sub-Types where there is a very high likelihood of encountering enclosures – in essence a very high probability zone.

To do this the various combinations of Sub-Types were ranked according to their Kj values and the cut off point for the very high probability zone was identified as the point where the previously increasing cumulative Kj and/or Relative Gain values began to decline. Below this are a number of combinations of Medieval Enclosed Land Sub-Types, each capturing one or a small number of enclosures. These and Medieval Enclosed Land Sub-Types in which no enclosures are recorded made up the remainder of the high probability zone. The exception to this was land that at some point in its history had undergone significant change. This included Medieval Enclosed Land that in one or more time-slices was defined as Industrial (because mining had taken place there), or which in the 2011 time-slice was classed as major roads or some other Type within which significant below-ground disturbance had taken place. Land that had undergone this sort of destructive alteration was classed in the low probability zone because is unlikely that any enclosures will be found there in the future.

Land classed as farmstead, hamlet, village or town in the recent time-slices but which had been Medieval Enclosed Land in at least one previous time-slice was placed in the high probability zone. In some cases some polygons classed as Medieval Enclosed Land in the earlier time-slices had since ceased to be actively farmed and had reverted to Rough Ground. These polygons also were placed in the high probability zone of the model. All other Sub-Type combinations formed the low probability zone.

Table 77 shows the make-up of the very high probability zone of the regressive enclosures model for all four study areas and its performance is summarised in Table 76 below.

Probability zone	Area (sq km)	Enclosures	PA	PS	Kvamme's Gain
Very High	152.836	227	0.398	0.744	0.465
High*	221.315	259	0.576	0.849	0.321
Low	162.735	46	0.424	0.151	-1.810

Table 76. Results of the regressive model for all prehistoric and Romano-British enclosures in the Lowland Cornwall study areas. includes the very high probability zone*.

As can be seen, the overall high probability zone captures 85% of the enclosures in roughly 58% of the project area and produces a reasonable Kvamme's Gain of 0.321. Within this overall zone the very high probability zone captures 74% in 40% of the project area and has a Kvamme's Gain of 0.465. The low probability zone captures only 15% of the enclosures in 42% of the project area, so is well-defined. When this model is applied to only the high validity enclosures it achieves a more accurate and more precise performance. More than 80% of the high validity enclosures are captured in the very high probability zone and almost 89% in the overall high probability zone, whilst there are only 11% of the enclosures in the low probability zone.

The very high probability zone is formed by a total of 49 Sub-Type combinations. The four highest-ranked are clearly the most important as these are the only ones capturing more than 10 enclosures. The fourth highest-ranked combination consists of MD derived from Cropping Units in all four time-slices, the highest-ranked is formed by MD derived from Cropping Units in the medieval, 1840 and 1880 time-slices and MD Altered field patterns (Amalgamated) in the 2011 time-slice. The second and third-ranked combinations also have MD Altered field patterns (Amalgamated) in their 2011 time-slice and MD derived from Cropping Units in their medieval time slice, with either MD Altered field patterns (Amalgamated) or MD Altered field patterns (Sub-Divided) in their 1840 and 1880 time-slices.

This model was then applied to each study area individually. The results were set out in detail in Lowland Cornwall volume 4 (section 14.1), but to summarise, the closest fit was achieved in the Pelynt study area, where the overall high probability zone captured 95.5% of the enclosures and the very high zone captured 82% (Fig 49). The very high probability zone achieved a Kvamme's Gain of 0.533 and the overall high probability zone 0.246.

The model provided a reasonably close fit in the Probus study area and in Penwith, although here the very high probability zone captured less the 70% of the enclosures. The model worked least well in Poundstock, where the very high probability zone captured 64% of the enclosures and the low probability zone captured 27% - far more than the other three study areas. When the model was applied to the high validity enclosures only, in all study areas except Pelynt, higher levels of accuracy and precision were achieved, particularly in Penwith, where the very high probability zone captured 77% of the enclosures.

2011	1880	1840	Medieval	Prehistoric	Enclosures	Area (sq km)
MD Altered field patterns (Amalgamated)	MD derived from Cropping Units	MD derived from Cropping Units	MD derived from Cropping Units		47	24.68
MD Altered field patterns (Amalgamated)	MD Altered field patterns (Sub-Divided)	MD Altered field patterns (Sub-Divided)	MD derived from Cropping Units		32	27.112
MD Altered field patterns (Amalgamated)	MD Altered field patterns (Amalgamated)	MD Altered field patterns (Sub-Divided)	MD derived from Cropping Units		26	21.613
MD derived from Cropping Units	MD derived from Cropping Units	MD derived from Cropping Units	MD derived from Cropping Units		30	30.225
MD Altered field patterns (Amalgamated)	MD Altered field patterns (Amalgamated)	MD Altered field patterns (Re-arranged)	MD derived from Cropping Units		7	4.369
MD Altered field patterns (Amalgamated)	MD Altered field patterns (Amalgamated)	MD peripheral fields	MD peripheral fields		4	1.238
PX Altered field patterns (Amalgamated)	PX Altered field patterns (Amalgamated)	PX Altered field patterns (Amalgamated)	PX field patterns		4	2.335
MD Altered field patterns (Sub-Divided)	MD Altered field patterns (Re-arranged)	MD Altered field patterns (Re-arranged)	MD derived from Cropping Units		5	3.579
MD Altered field patterns (Re-arranged)	MD Altered field patterns (Re-arranged)	MD Altered field patterns (Re-arranged)	MD derived from Cropping Units		8	8.413
PX Altered field patterns (Amalgamated)	PX Altered field patterns (Amalgamated)	PX Altered field patterns (Amalgamated)	Upland Rough Ground (undivided)		3	0.113
PX Altered field patterns (Amalgamated)	PX Altered field patterns (Amalgamated)	PX Altered field patterns (Sub-Divided)	PX field patterns		3	0.168
MD Altered field patterns (Amalgamated)	MD Altered field patterns (Amalgamated)	MD Altered field patterns (Amalgamated)	MD derived from Cropping Units		3	1.308
MD Altered field patterns (Sub-Divided)	MD Altered field patterns (Sub-Divided)	MD derived from Cropping Units	MD derived from Cropping Units		3	1.308
MD Altered field patterns (Sub-Divided)	MD peripheral fields	MD peripheral fields	MD peripheral fields		2	0.11
MD Altered field patterns (Sub-Divided)	MD Altered field patterns (Amalgamated)	MD Altered field patterns (Amalgamated)	MD derived from Cropping Units		2	0.257
MD Altered field patterns (Amalgamated)	MD Altered field patterns (Re-arranged)	MD Altered field patterns (Re-arranged)	MD derived from Strip Fields (Enclosed)		3	2.458
MD Altered field patterns (Re-arranged)	MD derived from Strip Fields (Enclosed)	MD derived from Strip Fields (Enclosed)	MD derived from Strip Fields (Enclosed)		2	0.614
MD Altered field patterns (Amalgamated)	MD Altered field patterns (Sub-Divided)	MD derived from Cropping Units	MD derived from Cropping Units		3	2.523
MD Altered field patterns (Re-arranged)	MD Altered field patterns (Amalgamated)	MD derived from Cropping Units	MD derived from Cropping Units		2	1.595
MD Altered field patterns (Sub-Divided)	MD Altered field patterns (Sub-Divided)	MD Altered field patterns (Sub-Divided)	MD derived from Cropping Units		7	8.619
PX Altered field patterns (Amalgamated)	PX Altered field patterns (Amalgamated)	PX field patterns	PX field patterns		3	0.161
Mod Intakes	Upland Rough Ground (divided)	Upland Rough Ground (divided)	Upland Rough Ground (undivided)	PX field patterns	1	0.016
Town	Town	MD Altered field patterns (Sub-Divided)	MD derived from Cropping Units		1	0.038
Campsite, chalet park etc.	MD Altered field patterns (Sub-Divided)	MD Altered field patterns (Sub-Divided)	MD derived from Cropping Units		1	0.086
Hamlet	MD Altered field patterns (Amalgamated)	MD Altered field patterns (Sub-Divided)	MD derived from Strip Fields (Enclosed)		1	0.088
MD Altered field patterns (Amalgamated)	Valley Rough Ground (divided)	MD Altered field patterns (Sub-Divided)	MD derived from Cropping Units		1	0.089
MD derived from Cropping Units	MD Altered field patterns (Sub-Divided)	MD derived from Cropping Units	MD derived from Cropping Units		1	0.092
Town	MD Altered field patterns (Amalgamated)	MD Altered field patterns (Re-arranged)	MD derived from Strip Fields (Enclosed)		1	0.102
Valley Rough Ground (divided)	Valley Rough Ground (divided)	Valley Rough Ground (divided)	Valley Rough Ground (undivided)	PX field patterns	1	0.106
MD Altered field patterns (Re-arranged)	Upland Rough Ground (divided)	Upland Rough Ground (divided)	MD peripheral fields		1	0.119
PX Altered field patterns (Amalgamated)	PX Altered field patterns (Sub-Divided)	PX Altered field patterns (Amalgamated)	PX field patterns		1	0.122
PX Altered field patterns (Amalgamated)	PX Altered field patterns (Amalgamated)	PX Altered field patterns (Re-arranged)	PX Altered field patterns (Amalgamated)	PX field patterns	1	0.153
Farmstead	MD Altered field patterns (Sub-Divided)	MD Altered field patterns (Sub-Divided)	MD derived from Cropping Units		1	0.481
MD Altered field patterns (Amalgamated)	MD Altered field patterns (Sub-Divided)	MD peripheral fields	MD peripheral fields		1	0.16
MD Altered field patterns (Re-arranged)	MD Altered field patterns (Sub-Divided)	MD Altered field patterns (Sub-Divided)	MD peripheral fields		1	0.231
MD Altered field patterns (Sub-Divided)	MD derived from Cropping Units	MD Altered field patterns (Sub-Divided)	MD derived from Cropping Units		1	0.235
MD Altered field patterns (Re-arranged)	Upland Rough Ground (divided)	Upland Rough Ground (divided)	MD derived from Cropping Units		1	0.276
Town	MD Altered field patterns (Sub-Divided)	MD Altered field patterns (Sub-Divided)	MD derived from Strip Fields (Enclosed)		1	0.287
Village	MD Altered field patterns (Re-arranged)	MD Altered field patterns (Re-arranged)	MD derived from Cropping Units		1	0.314
MD Altered field patterns (Sub-Divided)	MD Altered field patterns (Amalgamated)	MD derived from Cropping Units	MD derived from Cropping Units		1	0.358
MD Altered field patterns (Sub-Divided)	MD Altered field patterns (Amalgamated)	MD Altered field patterns (Sub-Divided)	MD derived from Strip Fields (Enclosed)		1	0.434
PX Altered field patterns (Amalgamated)	PX Altered field patterns (Amalgamated)	PX Altered field patterns (Sub-Divided)	PX Altered field patterns (Amalgamated)	PX field patterns	1	0.442
MD Altered field patterns (Amalgamated)	MD Altered field patterns (Amalgamated)	MD Altered field patterns (Amalgamated)	MD derived from Strip Fields (Enclosed)		1	0.443
MD Altered field patterns (Re-arranged)	MD Altered field patterns (Amalgamated)	MD Altered field patterns (Re-arranged)	MD derived from Strip Fields (Enclosed)		1	0.638
PX Altered field patterns (Re-arranged)	PX Altered field patterns (Amalgamated)	PX Altered field patterns (Amalgamated)	PX field patterns		1	0.652

2011	1880	1840	Medieval	Prehistoric	Enclosures	Area (sq km)
MD Altered field patterns (Amalgamated)	MD Altered field patterns (Re-arranged)	MD derived from Cropping Units	MD derived from Cropping Units		1	0.869
MD peripheral fields	MD peripheral fields	MD peripheral fields	MD peripheral fields		1	0.896
MD Altered field patterns (Re-arranged)	MD Altered field patterns (Sub-Divided)	MD Altered field patterns (Re-arranged)	MD derived from Cropping Units		1	1.091
MD Altered field patterns (Amalgamated)	MD Altered field patterns (Re-arranged)	MD Altered field patterns (Sub-Divided)	MD derived from Cropping Units		1	1.22
Total					**227**	**152.836**

Table 77. The very high probability zone of the regressive enclosures model for all four study areas.

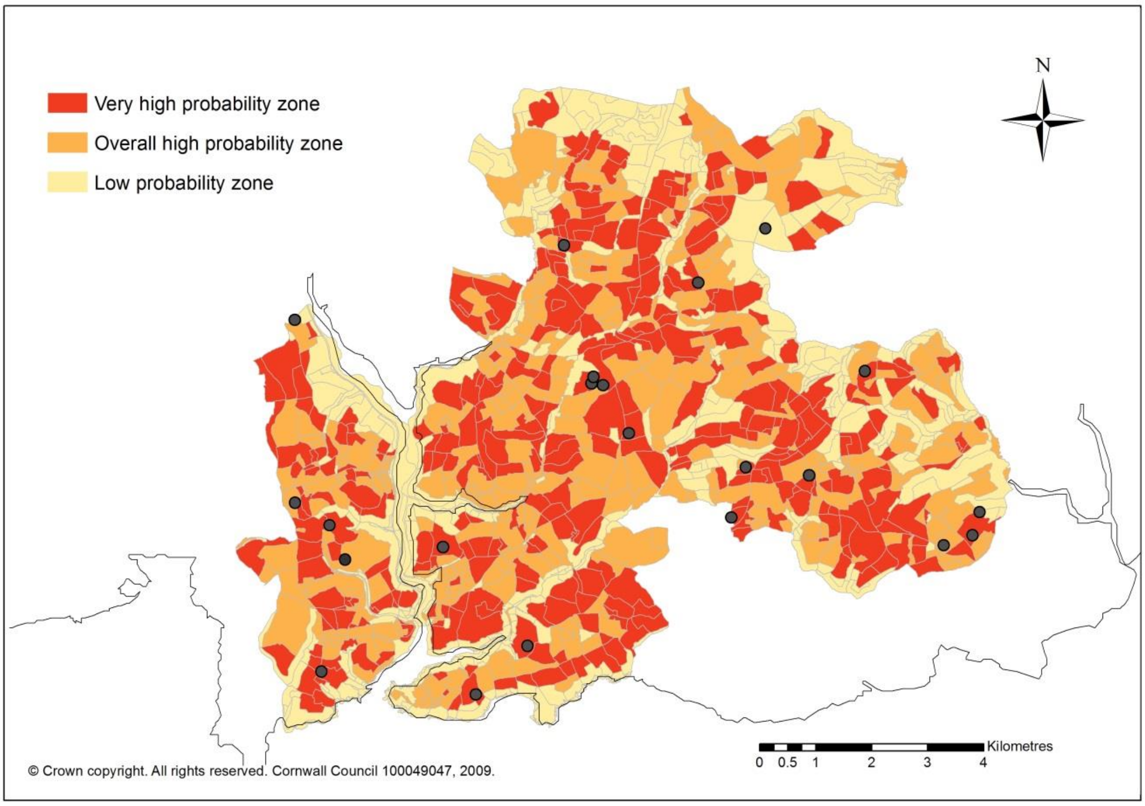

Fig 49. The regressive model for all enclosures applied to the Pelynt study area. Points show the distribution of enclosures.

Regressive models were built for each of the study areas and all achieved very high levels of accuracy, their very high probability zones capturing between 70% (Poundstock) and 91% (Pelynt) of the enclosures and good precision, producing Kvamme's Gains ranging from 0.387 (Probus) to 0.679 (Pelynt). The Pelynt model had the best performance both in terms of its very high probability zone and its overall high probability zone, which captured 95.5% of the enclosures and produced a Kvamme's Gain of 0.247 (by contrast the overall high probability zone of the Poundstock model produced a low Kvamme's Gain of 0.128).

It is of interest to compare the map produced by the regressive model of the Pelynt study area (Fig 50) with that produced by applying the regressive model for all enclosures to the Pelynt study area (Fig 49). Although the overall high probability zones of the two are identical (being formed by land classed as Medieval Enclosed in at least one time-slice), there are differences in the definition of the very high probability zones, particularly in the southwestern part of the study area. The very high probability zone of the Pelynt enclosures model is considerably more precise than that of the all enclosures model applied to Pelynt: the former covers 29% of the study area, whilst the latter covers 38%. Despite this, the Pelynt enclosures model captures 91% of the enclosures in its very high probability zone as opposed to 82% captured by the all enclosures model. In fact a single enclosure is captured in the low probability zone of the Pelynt enclosures model: the remainder are all captured in the very high probability zone.

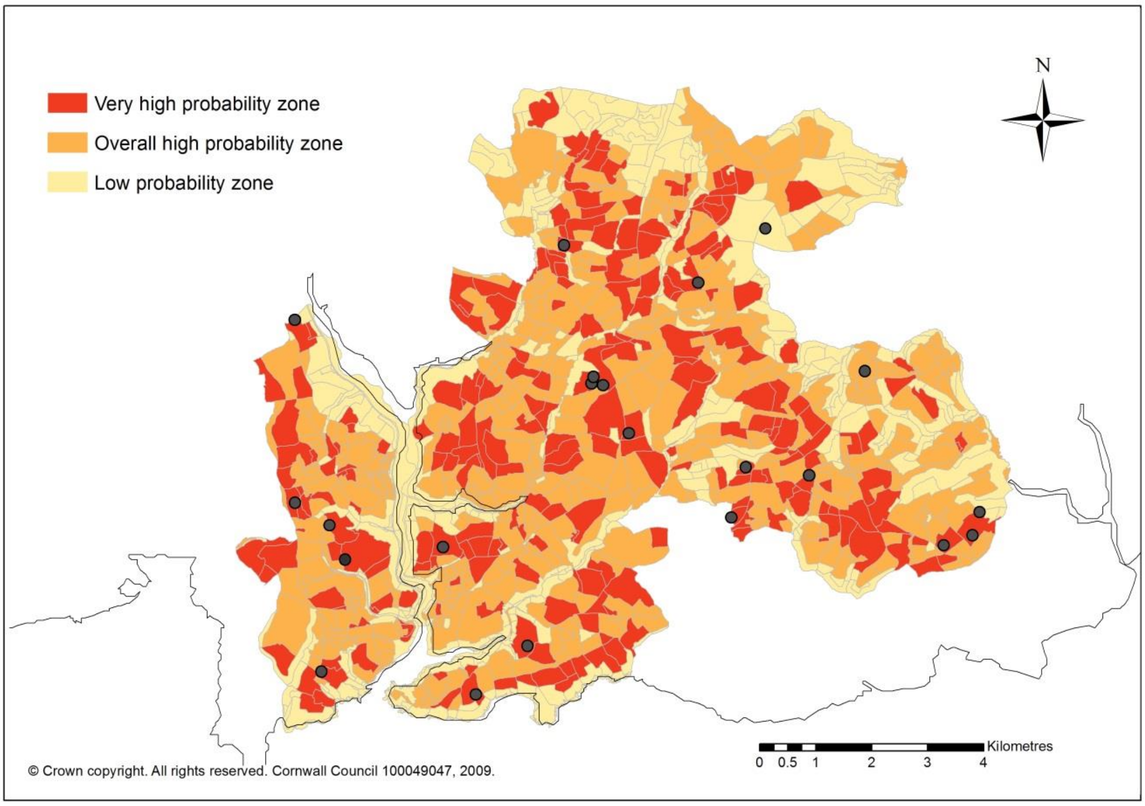

Fig 50. The regressive enclosures model for the Pelynt study area. Points show the distribution of enclosures in Pelynt.

This type of variance between the performance of the very high probability zones of the individual study area models and that of the all enclosures model was evident in all four study areas, suggesting there are regional differences in the HLC and in enclosure distribution from area to area. This was confirmed when the models were tested using partial data. Testing was done by creating a model using data from three study areas and then applying this to the fourth. Having created the model the number of enclosures per square kilometre captured in each of its probability zones was calculated. This figure was then used to predict the number of enclosures (and the expected PS value) one could expect to be captured in each probability zone when the test model was applied to the fourth study area. This process was repeated for all four study areas.

Once again the best fit was achieved by the Pelynt study area when the Probus, Penwith and Poundstock model was applied. It was predicted that 16 enclosures would be captured in the very high probability zone, 19 in the overall high probability zone and three in the low probability zone. In the event 16 were indeed captured in the very high probability zone and only one in the low probability zone, so it could be argued that the test model performed better than expected.

However, testing of the other three study areas was less conclusive. When the Penwith, Pelynt and Poundstock model was applied to the Probus study area only 75 enclosures were captured in the very high probability zone as opposed to the 96 predicted. On the other hand, 129 enclosures were captured in the overall high probability zone rather than the 119 expected, so the low probability zone was very accurately predicted. A similar result was achieved when the Penwith study area was tested: the overall high probability zone captured 85 enclosures (it was predicted to capture 86) but the very high probability zone captured 41 rather than 67 as predicted. However, it should be borne in mind that Prehistoric Enclosed Land forms part of the very high probability zone in Penwith, but is not recorded from the other three study areas. So Prehistoric

Enclosed Land made up part of the overall high probability zone of the Probus, Pelynt and Poundstock model rather than the very high probability zone. Nineteen enclosures are located in Prehistoric Enclosed Land in Penwith, so had this Type been included in the very high probability zone, it would have captured a total of 60 enclosures – much closer to the 67 predicted.

The Poundstock study area produced the worst test result. Here only half the number of enclosures predicted was captured in the very high probability zone (Table 78 and Fig 51).

Probability zone	Predicted PS	Actual PS	Predicted enclosures	Actual enclosures
Overall high*	0.810	0.727	27	24
Very high	0.655	0.333	22	11
Low	0.190	0.273	6	9

*Table 78. Results of testing the Probus, Penwith and Pelynt model against the Poundstock study area. *Overall high probability zone includes the very high probability zone.*

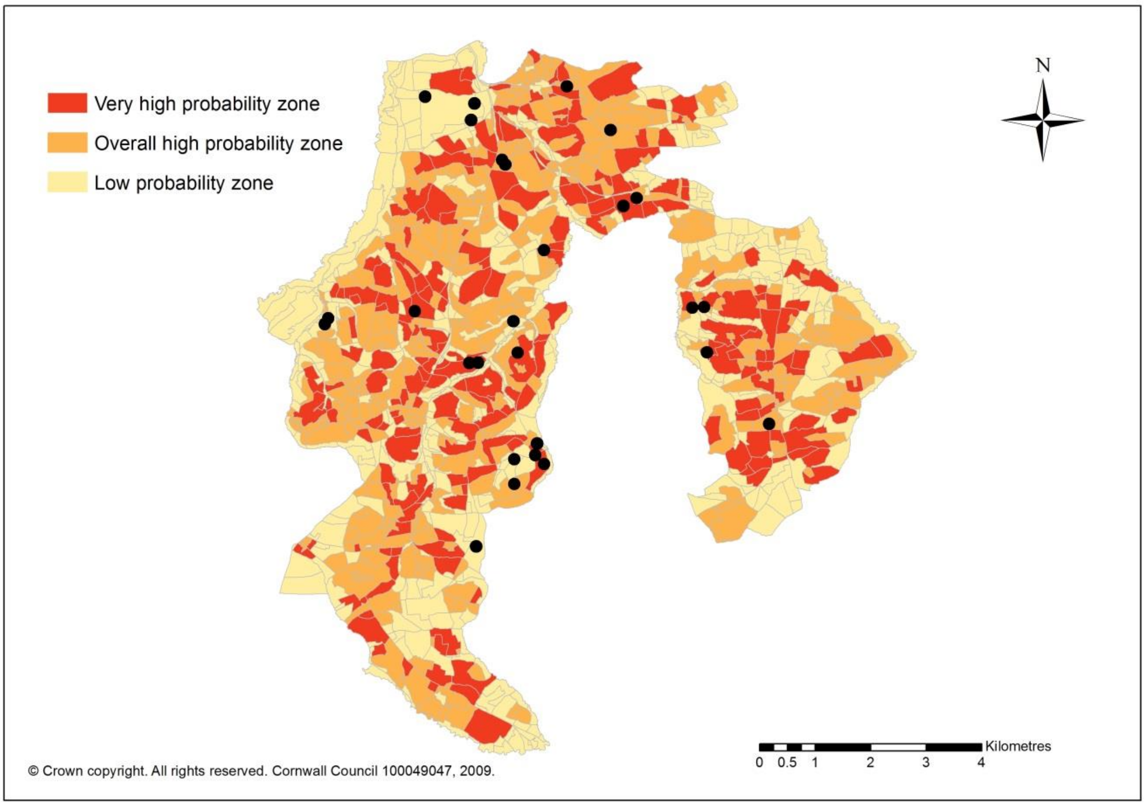

Fig 51. The Probus, Penwith and Pelynt enclosures model applied to the Poundstock study area. Points show the distribution of enclosures.

To some extent the reasons why the test results were not very conclusive may be the considerable differences in size of the four study areas and variations in the historic landscape character between them. For example, as already mentioned, the highest ranked Sub-Type time-slice combination in the all enclosures model contained the following Sub-Types.

Time-slice	HLC Sub-Type
2011	MD Altered field patterns (Amalgamated)
1880	MD derived from Cropping Units
1840	MD derived from Cropping Units
Medieval	MD derived from Cropping Units

This combination captured 47 enclosures and covered 24.68 km sq. However the Probus study area contains 65% of the total extent of this Sub-Type combination and 39 of the total number of enclosures captured within it (this is more than the total number of enclosures in either the Pelynt or Poundstock study areas). In fact, although this combination forms part of the very high probability zone in Probus and Penwith it is not included in the corresponding zones in the Pelynt or Poundstock models. Another example of the uneven spread of Sub-Type combinations is that in which the Sub-Type throughout all time-slices is MD derived from Cropping Units. The Probus study area contains 72% of the total extent of this combination, and it is ranked second in the Probus model. However, this combination is not in the very high probability zones of the Penwith or Poundstock models. Thus it appears that, because of its large size, the Probus study area may have had a disproportionate influence on the all enclosures model.

To test the models in a way that as far as possible neutralised the effects of these regional and size variations, two test areas of roughly equal size were created by taking a number of parishes from each study area and grouping them together. Each of these two test areas were made up of land covering slightly more than 30km sq from each study area. Models were then created for each test area and applied to the other.

Neither test could be described as successful: testing Area 1 with the Area 2 model produced the least satisfactory outcome (Table 79).

Probability zone	Predicted PS	Actual PS	Predicted enclosures	Actual enclosures
Overall high*	0.936	0.825	107	94
Very high	0.90	0.561	103	64
Low	0.064	0.175	7	20

*Table 79. Results of testing the Area 2 model against the Area 1 enclosures. *Overall high probability zone includes the very high probability zone.*

The worst aspect of this test result is not that far fewer than predicted enclosures were captured in the very high probability zone of the model, but that the low probability zone captured three times more enclosures than predicted. By contrast, when the Area 2 enclosures were tested by applying the Area 1 model only seven enclosures were captured in the low probability zone as opposed to the 21 predicted and the overall high probability zone captured 81 enclosures rather than the 67 predicted (the very high probability zone captured 25% fewer enclosures than predicted).

When the models and the partial data tests are considered as a whole, while it is clear that accurate and precise models can be created for each individual study area, it is equally clear that it is not possible to successfully apply these models to the other study areas. Regional differences in the make-up of the HLC and the distribution of the enclosures across the study areas mean the fine-grained very high probability zones cannot be applied across the board with any great consistency. In all study areas except Pelynt fewer enclosures than predicted were captured in the very high probability zones of the test models. On the other hand, the overall high probability zones, formed by Medieval Enclosed Land (with Prehistoric Enclosed Land in Penwith), did accurately identify those areas where the highest numbers of enclosures are to be found. In some study areas more enclosures than predicted were captured in this zone, even in Poundstock where the tests performed worst, the actual number captured was not too far from the predicted number (72.7% as opposed to 81%).

Although the Kvamme's Gains produced by the overall high probability zones of these models are not especially high, all except those for the Poundstock study area are higher than the Kvamme's Gain produced by the 1994 HLC model. At 0.352 the gain measure for the high probability zone of the all enclosures model is more than twice the 0.172 produced by the 1994 model. Pelynt achieved a Kvamme's Gain of 0.247, Probus 0.220 and Penwith 0.187.

Although there are differences from study area to study area in the make-up of the very high probability zones of the models, there does appear to be a factor common to all. This is the predominance of Altered field patterns (Amalgamated), whether Medieval or Prehistoric Enclosed, among the highest-ranked Sub-Types. Even in the Poundstock model, where this is less obvious, combinations of Sub-Types with MD Altered field patterns (Amalgamated) in the 2011 time-slice make up a third of the total number of combinations in the very high probability zone. The importance of MD Altered field patterns (Amalgamated) in terms of predicting the location of enclosures is greatest when at least one of the previous time-slices is classed as MD derived from Cropping Units.

In fact land classed as either medieval or prehistoric amalgamated fields in the 2011 time-slice covers 34% of the four study areas and captures 54% of the enclosures. If land classed as cropping units in the 2011 time-slice is included 64% of the enclosures are captured in 43% of the study areas. Amalgamation – the removal of field boundaries and resulting enlargement of field size – seems to be a key factor in the location, or at least the detection, of enclosures. Although MD Altered field patterns (Amalgamated) is a recent HLC land class it should be borne in mind that the grouping of medieval strip fields into cropping units is a form of 'amalgamation' in itself.

This raises the question of whether the enlargement of fields, thereby enabling them to be brought under modern arable cultivation more profitably, simply means there is more likelihood of detecting below-ground archaeology, especially given that almost 60% of the enclosures are recorded as cropmarks. Alternatively it may be that the fields were amalgamated because they have always been the best quality farmland and it follows that this is precisely where later prehistoric and Romano-British settlements are most likely to have been established.

In this regard it is pertinent to note that of the 51 enclosures recorded as extant earthworks 32 are located in land classed as either amalgamated or as derived from cropping units in the 2011 time-slice. This equates to 63% of the earthwork enclosures, which suggests that the amalgamated fields are not merely those in which cropmarks are most likely to be recorded but may represent the favoured areas for settlement and farming.

13.2.2 Barrows

The principal Types forming the high probability zone of the high level 1994 HLC model for barrows in lowland Cornwall were Recently Enclosed Land Types (Farmland Post Medieval and Farmland C20), Rough Ground and Farmland Prehistoric. Between them these Types captured 61% of the barrows within 37% of the study area and produced a Kvamme's Gain of 0.397, so this model is reasonably accurate and precise. The weakness of the model is the large size of the medium probability zone, made up principally of Farmland: Medieval. This zone covers more than half of the Lowland Cornwall study area and also captures 32% of the barrows – twice as many as any other HLC Type.

When this model was applied to the four study areas the results were very mixed. The model performed well in the Poundstock study area, being accurate and reasonably precise, but whilst its high probability zone captured 89% of the barrows in the Penwith study area, here it lacked precision. In both the Probus and Pelynt study areas the medium probability zone captured more barrows than the high probability zone – twice as many in the case of Pelynt.

There are some mitigating factors to account for these inconsistent results. For instance the area taken up by Rough Ground and Recently Enclosed Land in the Pelynt study area is very small; hence the low number of barrows captured by the high probability zone. Furthermore large parts of the Penwith study area contained land classed in the 1994 HLC as Farmland Prehistoric, hence the lack of precision (even though much of this land has been reinterpreted as Medieval Enclosed Land). Overall the results illustrate that when applying a high level county-wide model to specific local areas, in some it performs as expected; in others less so or not at all.

Generally speaking the Lowland Cornwall HLC models based on HLC Types perform better than the 1994 model. All are more accurate: for instance in the Probus study area although the high probability zones of all four time-slice models capture less than 60% of the barrows, this is better than the 47.6% captured by the high probability zone of the 1994 model. Furthermore in both the Pelynt and Penwith study areas some of the time-slices produce two-zone, barrows/no barrows models which are obviously extremely accurate. In terms of precision the performance of the models is mixed: in Poundstock Kvamme's Gains range from 0.590 to 0.760 from time-slice to time-slice compared with the 0.473 achieved by the 1994 model, and in Probus the gains are almost as high. However, the Lowland Cornwall models for Penwith and Pelynt are less precise than the 1994 model.

In both Probus and Poundstock the high probability zones of the models are formed by the HLC Types one might expect given the make-up of the 1994 high probability zone: that is, the zones are dominated by Recently Enclosed Land and Rough Ground Types. This is clearest in Poundstock, where the medieval time-slice model has a high probability zone made up exclusively of Rough Ground Types. By contrast in the Pelynt study area the high probability zones for all four time-slices are formed of Medieval Enclosed Land; in the Penwith study area there is no clear pattern with the high probability zones containing a range of Types: for instance, the high probability zone of the medieval time-slice model is made up of Rough Ground, Prehistoric Enclosed Land and Medieval Enclosed Land.

There are factors to account for some of these difficulties. The small extent of Rough Ground and Recently Enclosed Land in Pelynt is mentioned above and this might explain why Medieval Enclosed Land is consistently the highest-ranked Type in all four time-slices. In Penwith much of the land classed as Farmland Prehistoric in the 1994 HLC has been reinterpreted as Medieval Enclosed Land in the Lowland Cornwall HLC. However, much of the Medieval Enclosed Land can be seen as altered Prehistoric Enclosed Land.

When the models are made using HLC Sub-Types as variables the results are in the main more accurate than the models made with HLC Types and most are more precise. In all except Pelynt the high probability zones are dominated by Recently Enclosed Land and Rough Ground Sub-Types. However, in Penwith the high probability zones for some time-slices contain Medieval Enclosed Land Sub-Types and the overall impression of the Penwith models is that there is no real pattern to the make-up of the high probability zones: these containing a mixture of Rough Ground, Recently Enclosed, Medieval Enclosed and Prehistoric Enclosed Land Sub-Types (Table 80).

	HLC Sub-Types	Barrows	PA	PS	Kj	Rel gain
1	Upland Rough Ground (divided)	9	0.057	0.196	0.165	0.138
2	MD Altered field patterns (Re-arranged)	7	0.086	0.152	0.267	0.205
3	MD Altered field patterns (Amalgamated)	8	0.180	0.174	0.322	0.199
4	PM Intakes	3	0.031	0.065	0.370	0.233
5	PX Altered field patterns (Amalgamated)	3	0.057	0.065	0.397	0.241
6	PM Altered field patterns (Amalgamated)	2	0.027	0.043	0.424	0.258
	Total	**32**	**0.438**	**0.695**		

Table 80. Penwith study area 1880 time-slice: all barrows. HLC Sub-Types making up the high probability zone.

In the Probus study area there are questions as to whether to include Medieval Enclosed Land Sub-Types in the high probability zones of the 1880 and 1840 time-slice models – they were included in order to favour accuracy over precision. Even in the Poundstock study area, where the predominance of Recently Enclosed Land and Rough Ground in the high probability zones was clearest, when the models are based on Sub-Types the 1880 and 2011 high probability zones contain Medieval Enclosed Land Sub-Types (Table 81).

	HLC Sub-Types	Barrows	PA	PS	Kj	Rel gain
1	PM Altered field patterns (Amalgamated)	9	0.037	0.184	0.164	0.146
2	PM Intakes	8	0.049	0.163	0.301	0.261
3	MD Altered field patterns (Amalgamated)	10	0.205	0.204	0.379	0.260
4	Coastal Rough Ground (divided)	5	0.015	0.102	0.477	0.348
5	Emod Intakes	5	0.036	0.102	0.559	0.414
6	Upland Rough Ground (divided)	5	0.071	0.102	0.617	0.445
7	Coastal Rough Ground (undivided)	1	0.005	0.020	0.636	0.460
8	PM Altered field patterns (Sub-Divided)	1	0.006	0.020	0.653	0.475
	Total	**44**	**0.424**	**0.897**		

Table 81. Poundstock study area 1880 time-slice: all barrows. HLC Sub-Types making up the high probability zone.

When only the high validity barrows are modelled the results are generally similar or very similar to the models for all barrows. They also tend to be more accurate and precise, although in the Poundstock study area most are slightly less accurate. On the whole they also indicate more clearly that Rough Ground and Recently Enclosed Land Types and Sub-Types are the areas of high probability. For instance in the Probus study area the high probability zones of the 1840 time-slice models do not contain any Medieval Enclosed Land Sub-Types (Table 82). In fact Probus is the only study area where the models for high validity barrows are notably different from those for all barrows. The main cause of the difference appears to be the large number of low or zero validity barrows, especially those recorded from documentary evidence, these being located in Medieval Enclosed Land; further work might include research on the veracity of these records. This difference is not apparent in the other three study areas. In fact in the Pelynt study area there are equal numbers of high validity and other barrows located in Medieval Enclosed Land, and in Poundstock there are more high validity barrows than those with a low or zero validity.

	All Probus barrows		High validity Probus barrows
1	Upland Rough Ground (undivided)	1	PM Intakes
2	PM Intakes	2	Upland Rough Ground (undivided)
3	Upland Rough Ground (divided)	3	Upland Rough Ground (divided)
4	Emod Intakes	4	Emod Intakes
5	MD derived from Strip Fields (Enclosed)	5	Valley Rough Ground (divided)
6	Emod New Farms (>5ha)		
7	Parkland		
8	MD derived from Cropping Units		

Table 82. Make-up of the high probability zones of the all barrows and high validity barrows models for the Probus study area: 1840 time-slice.

Overall the models, especially those based on HLC Types, do indicate that Recently Enclosed Land, Prehistoric Enclosed Land and Rough Ground are the Types where barrows are most likely to be located, but this is by no means definitive. There are also substantial numbers of barrows in Medieval Enclosed Land and in some parts of the county there are more barrows in Medieval Enclosed Land than any other HLC Type, so the models are to an extent inconclusive.

This is borne out by the model for all the Lowland Cornwall barrows, which is very accurate and reasonably precise, with a Kvamme's Gain of 0.315. The high probability zone of this model is made up of a combination of Modern, Early modern, Post-Medieval, Medieval and Prehistoric Enclosed Land Sub-Types as well as Coastal Rough Ground.

	HLC Sub-Types	Barrows	PA	PS	Kj	Rel gain
	High probability zone					
1	Mod Intakes	35	0.052	0.153	0.124	0.101
2	MD Altered field patterns (Amalgamated)	76	0.334	0.332	0.219	0.099
3	PM Altered field patterns (Amalgamated)	25	0.038	0.109	0.318	0.170
4	MD derived from Cropping Units	18	0.080	0.079	0.336	0.168
5	PM Altered field patterns (Sub-Divided)	8	0.008	0.035	0.372	0.195
6	Emod Altered field patterns (Amalgamated)	9	0.033	0.039	0.388	0.202
7	Woodland mixed	6	0.009	0.026	0.411	0.219
8	Emod Intakes	5	0.013	0.022	0.426	0.228
9	PX Altered field patterns (Re-arranged)	4	0.003	0.017	0.444	0.242
10	Plantation	4	0.005	0.017	0.460	0.255
11	Coastal Rough Ground (divided)	4	0.006	0.017	0.475	0.267
	Total	**194**	**0.581**	**0.846**		
	Medium probability zone					
12	MD Altered field patterns (Sub-Divided)	8	0.076	0.035	0.447	0.226
13	Upland Rough Ground (undivided)	3	0.005	0.013	0.458	0.234
14	PM Intakes	3	0.016	0.013	0.459	0.232
15	Mod New Farms (>5ha)	2	0.001	0.009	0.469	0.240
16	PX Altered field patterns (Amalgamated)	2	0.013	0.009	0.467	0.235

17	Town	2	0.014	0.009	0.464	0.230
	Total	**20**	**0.125**	**0.088**		

Table 83. The high and medium probability zones of the 2011 time-slice model for all barrows in the Lowland Cornwall project area.

It seems likely that the majority of barrows awaiting future discovery have no detectable above-ground remains and will be found in ploughed land. So in terms of predicting where they might be found, Prehistoric Enclosed Land, Recently Enclosed Land and Medieval Enclosed Land are the most likely locations.

14 HLC and predictive modelling

14.1 Why do predictive modelling?

In his introduction to predictive modelling Philip Verhagen sets out the practical reasons for producing predictive models in archaeology: "when time and money do not allow a complete archaeological survey of an area, a predictive model can serve as a tool for the selection of the areas that are most likely to contain the archaeological phenomena of interest. Survey will then concentrate on these zones, and a maximum return on investment is obtained. This situation is commonly encountered in cultural resource management, where archaeologists are forced to decide what to investigate within the constraints of tight budgets and time schedules" (Verhagen 2007, 13).

In Cornwall, and other regions of England, predictive models can be used on a broader level to identify those areas of the county with high archaeological potential. In the event that developments which may impact on the historic environment are proposed within those areas, the model will form the basis of advice provided to planners that some form of archaeological mitigation on the development is required. This is the case regardless of whether or not archaeological features are recorded in the SMR at those sites.

Analysis of the Cornwall Events Record during this project certainly highlighted the need for some mechanism to identify areas of high archaeological potential across the county. Taking the number of previously unrecorded sites found as a result of the Events and dividing this by the total area surveyed by the Events, we arrive at a figure for the number of previously unrecorded sites per square kilometre in the Events Record. By extrapolating this across the total area covered by Lowland Cornwall a rough figure for the potential number of sites awaiting discovery can be suggested. While admittedly a crude calculation, this indicates that if the whole of Lowland Cornwall was subjected to archaeological investigation we could expect to find 1,854 new enclosures, 2,134 roundhouses, 1,011 field systems and 618 barrows.

On a more strategic level predictive models could also be used to influence decisions on where developments are proposed. An example of this is the sensitivity map produced by Cornwall Council around 2005 showing zones of high, medium and low archaeological sensitivity to the impact of biomass plantations at a time when a number of these were proposed. Or as Verhagen puts it, "The designation of archaeologically important zones by means of predictive modelling can also be used to try to convince developers to choose the areas with the least 'archaeological risk' for their plans" (*ibid*, 13). Of course this approach carries the risk of the destruction of archaeology if the model has incorrectly identified an area as being low probability: this issue is discussed further below.

14.2 HLC as a variable

While Cornwall's HLC was not conceived as a predictive model *per se* at the time of its implementation in 1994, its potential application as a predictive tool was recognised from the outset. In effect HLC has been used for some time in Cornwall as a 'deductive' or 'theory driven' predictive model based on expert judgement, that judgement being that there is the potential for much below-ground archaeological material to be present in land classed as the HLC Zone Anciently Enclosed Land (AEL). To formalise this, a template was developed by Cornwall's curatorial archaeologists tasked with providing advice to planning officers. This includes the following wording:

"The proposed application is on land recorded by the Cornwall and Scilly Historic Environment Record as being 'Anciently Enclosed Land' (AEL). The Cornwall Landscape Assessment 1994 describes AEL as:

Typical Historical/Archaeological Components

Much important archaeological material will survive below the surface, including the Bronze Age, Iron Age and Romano-British settlements and fields of the farmers who originally cleared this zone.

Potential for historical and archaeological research

Considerable. Each farming settlement will contain a wealth of historical, architectural and archaeological information. Surveys of field systems yield considerable agricultural, social and tenurial information. Buried archaeological features can be expected anywhere in this zone.

We recommend that an archaeological geophysical survey is undertaken prior to determination to ascertain the buried archaeological potential of the site. This information is in line with National Planning Policy Statement paragraph 128 and may inform the proposed layout of the development and may lead to further archaeological works."

To their credit, Cornwall Council's planners have accepted this argument and as a result over the years numerous archaeological features, which otherwise would have been destroyed without record, have been identified, excavated and reported. Beyond the broad statement that AEL is a zone of high potential, the advice given to planners is guided first by the sample size required proportionate to the development, and second by the type of AEL and its past history. With regard to sample size one former Archaeological Advice Officer suggested that a 20ha site will possibly have a close to 100% probability of features worthy of excavation rather than just a watching brief (Daniel Ratcliffe pers. comm.). As for the type of AEL, this is not currently well represented in Cornwall's GIS mapping of HLC. In particular no distinction is made between Modern Enclosed Land which is former rough ground and that which is altered AEL. This is an issue arising from the early stage of HLC development during which the 1994 HLC was undertaken. There will be less risk of similar issues arising for later attribute-led HLCs elsewhere.

One of the principal aims of the Lowland Cornwall project was to deepen or refine the 1994 HLC to explore the possibility that some types of AEL have higher potential for below-ground archaeology than others. At the same time it would identify those tracts of Modern Enclosed Land which are modified AEL.

A further consideration is that, although widely accepted, the idea that AEL is the zone of high potential has not been tested in a systematic way. Additionally some Bronze Age, Iron Age and Romano-British settlements and fields have been found in land classed as Recently Enclosed Land and other HLC Zones as well as in AEL. It is also worth saying that analysis of the Events Record carried out during this project showed that whilst many more prehistoric/Romano-British settlement features have been found in AEL than other HLC Zones, it is also a fact that for a considerable number of Events no features were found in AEL. In fact more than half the total area surveyed by the Events in which no sites were found is made up of AEL, and no sites were found in a third of the total area of AEL surveyed. So in addition to creating predictive models based on the refined HLC, Lowland Cornwall provided an opportunity to validate the predictive capability of the existing HLC.

A criticism frequently levelled at archaeological predictive modelling is that it is environmentally deterministic in outlook, predominantly using variables such as soil type, geology, distance to open water, etc., as site predictors. That past human behaviour cannot be understood simply in terms of environment and economy but that social and cultural factors also determine this behaviour to a large extent and should therefore be additional predictors for the presence of archaeological remains.

One reason why predictive modelling has remained largely environmentally deterministic in outlook is that social and cultural factors are seen as too abstract and intangible for use in a predictive model. One answer is to use datasets such as HLC as the variable for modelling. The patterns on which the various HLC Types and Sub-Types are defined ultimately reflect deep patterns of land use and historical processes which are intrinsically cultural. Continuity of the cultural landscape is central to the idea that AEL, the medieval heartland, perpetuated the zone of settlement from prehistoric times, so much so that HLC brings a dimension which is of itself archaeological in character.

14.3 Methodology issues

14.3.1 Strengths and weaknesses of the data

All the models created in the project were 'inductive' or 'data driven'. Data driven models of this type involve seeing whether a relationship can be found between a sample of known archaeological sites and a selection of landscape characteristics, in this case HLC Types and Sub-Types. The data source used was the Cornwall SMR and it should be acknowledged that there are weaknesses in SMR data which mean that they are not ideal for use in a predictive model (section 6.2). Essentially these weaknesses boil down to the data contained in the SMR having been collected over a considerable period from different sources and of varying quality. A good example would be the difference in the SMR record between one area which has been subjected to detailed survey and a similar area which has not. However, not to use SMR data in projects such as this seems a waste of data, especially as SMRs have grown rapidly in recent years and are likely to continue growing.

Ideally data sources for predictive modelling should meet three conditions (Verhagen 2007, 147):

1. The sample size should be large enough to make the desired inferences with the desired precision
2. The sample areas should be representative of the study region
3. The survey methods should be chosen such that bias in site recording is avoided

For validation of the 1994 HLC the first two conditions were clearly met, but not the third. The models may have been influenced to a degree by inherent bias in the SMR data. This was clearly the case with the records for find spots, whose distribution almost certainly simply reflects the results of the work of a relatively small number of collectors (section 7.6).

To produce models based on the deepened HLC the overall sample size meets the first condition but it is debatable as to whether this is the case for all the individual study areas. In particular, the reliability of the enclosure models for the Pelynt and Poundstock study areas might be questioned, given the low numbers of enclosures recorded there (22 and 33 respectively).

By choosing four study areas from different geographical regions of the county the second condition was met, but this brought with it some disadvantages. Firstly, there were differences in the make-up of the models from one area to another, these in some cases being considerable. This meant it was difficult to produce overall models which worked consistently when applied to individual study areas. Secondly, these differences were probably compounded by differences in size between the study areas; the 135.5 sq km of Probus contrasting with the 65.6 sq km of Poundstock for instance. In fact because of its size and the high numbers of sites located within it, the Probus study area had a disproportionate influence on the overall models. With hindsight it might have been better to have defined four more similarly-sized study areas. One way of achieving this would be to base the study areas on OS grid tiles rather than ecclesiastical parishes, as was the case with Lowland Cornwall. This would have made it possible to define four study areas of exactly the same size. Finally, another result of having four study areas (and four time-slices) was that out of necessity a large number of models was produced, making the project reports long and repetitive. Those planning similar projects in the future should consider whether it would be preferable to use a single larger study area. Although this might miss some of the regional variations captured by multiple study areas, it would simplify what in any case is a complex project. If defined carefully a single study area may well be representative of the overall study region.

Consideration was given to the third condition during the building of the Lowland Cornwall HLC models. This involved comparing the models for all sites with those for the high validity sites only. In theory those sites with a low validity rating could be considered to be of doubtful provenance and there was the option to exclude them from the dataset if it was felt that they were skewing the resulting models. Only those sites mapped during Cornwall's NMP were assigned a validity rating and for the purposes of this project, sites not mapped by NMP were assumed to have a validity score of zero. In the model building process the only distinction made was between sites with high validity and all others, so it was difficult to distinguish between those sites which were genuinely questionable and those *bona fide* sites which, for one reason or another, were not mapped during the NMP.

In many cases there was little, if any, difference between the high validity models and those for all sites, but in some there were significant differences. For instance the high probability zone of the Penwith enclosures model (1880 time-slice) comprises eight Sub-Types including two Rough Ground Sub-Types, whereas the high probability zone of the corresponding model for high validity enclosures is made up of five Prehistoric and Medieval Enclosed Land Sub-Types only. In virtually every case models made using the high validity sites were more accurate and precise than those produced by the all sites models. It could be argued from this that only the high validity sites should have been used. However, when the models made from all sites are compared with those for high validity sites only, similar numbers of high validity sites are captured in both, so the decision was made to include all sites in the models but retain the high validity models for comparison.

For any similar project in the future this is an aspect that probably needs more thought at the outset. Some kind of interpretative confidence value should be attached to each site record rather than to a selection (i.e. only those mapped by NMP). In fact, it would be good practice for SMRs to include such a confidence value field as a matter of course. It might also have been beneficial to this project if only NMP data had been used as the dataset. Although Cornwall's NMP took 12 years to complete and involved three staff members, the basic methodology changed little over time and the mapping covered the whole county at the same level of detail, so as a dataset it is more consistent than the county SMR, which has been compiled by a range of individuals over a long period of time and to differing levels of detail.

14.3.2 The use of time-slices

Another aspect of the Lowland Cornwall project methodology needing consideration in relation to similar projects in the future is the use of four (five in the case of Penwith) time-slices. The thinking behind the use of time-slices was that they would provide a clearer understanding of landscape change over the last 175 years and beyond. In this regard the time-slices did prove useful in two respects, as outlined in section 11.7.6. In summary, they demonstrated that over the four study areas the extent of rough ground has diminished dramatically since the time of the late medieval time-slice, and that there has been a distinctive sequence of alterations to Medieval Enclosed field patterns over time, with episodes of subdivision of fields followed by amalgamation. This was the case in all four study areas so we can conclude that both patterns are countywide phenomena.

Beyond that the time-slices had only limited use in building the models. The medieval time-slice produced the simplest models which expressed the distribution patterns in the clearest terms. For instance the medieval time-slice model for the Probus enclosures has a high probability zone formed by a single HLC Type, Medieval Enclosed Land, and in the corresponding model based on Sub-Types the high probability zone is formed exclusively by medieval fields derived from cropping units. In the other time-slices for the Probus enclosures the high probability zones are dominated by Medieval Enclosed Land Sub-Types but with slight differences in their make-up. Most of the models followed this pattern, with only slight differences between their make-ups from time-slice to time-slice, making it difficult to gauge which time-slice produced the strongest model.

Models were made for the enclosures using a combination of all time-slices. These produced models with high and low probability zones, the high probability zones enclosing smaller very high probability zones. The very high probability zones of these models were considerably more precise than any of the other enclosures models, and were also very accurate in most cases. However, when they were tested by using partial data the results were inconclusive: in all study areas except Pelynt, fewer enclosures than predicted were captured in the very high probability zones (section 13.2.1 and Lowland Cornwall Volume 4, section 14.2). On the other hand, the overall probability zones were very accurate and were accurately predicted in the tests. So while the fine-grained very high probability zones are effective in a local context they cannot reliably be applied to the wider landscape. By contrast, the high level overall models could be applied countywide with confidence.

14.3.3 Accuracy and precision

The main issue with the overall models is although very accurate they lack precision. Indeed, Considering the project as a whole, relative lack of precision is a feature of many of the models. Ideally the high probability zone should capture the highest possible number of sites in the smallest possible area. Gibson (2005) suggests that a 'good working model' should capture at least 70% of sites in no more than 10% of the area, giving a Kvamme's Gain of 0.86 or more. Other than a few of the barrows models, none of the Lowland Cornwall models achieved anything like this very high level of performance. However, Kvamme's Gain measures do not cover all aspects of model performance: identical gains can be achieved by model A, capturing 60% of the sites in 30% of the area or by B, capturing 80% of sites in 40% of the area (Kvamme's Gain of 0.5). In model A, 40% of the sites are captured in the 70% of the area outside the high probability zone, whereas in model B only 20% of the sites are outside the high probability zone, in 60% of the area. There is, therefore, a greater chance of encountering a site outside the high probability zone in model A, so model B is the better performing of the two. So to measure the overall performance of the models the gain measures achieved by each zone should be compared by calculating the Indicative Value (PS/PA) for each probability zone. When measured in this way, for the most part the models perform reasonably well. For instance, the high probability zone of the 2011 time-slice model for Probus enclosures captures 73% of the sites in 50% of the area and one is 4.5 times more likely to encounter a site in the high probability zone than in the low probability zone.

While producing optimum model performance involves achieving the best balance between accuracy and precision, from a cultural resource management perspective accuracy is much the more important of the two. This is because archaeological planning conditions are less likely to be attached to developments taking place in areas of low potential. As a result, the less accurate the model, the greater is the risk to archaeology in the low probability zone. Some balance does, however, need to be struck between accuracy and precision: whereas planners will accept that some areas are of higher potential than others, they are unlikely to accept that the entire county, for instance, is of high potential.

The project has demonstrated that in Cornwall HLC can be used as a broad brush predictive tool to identify areas of high archaeological potential with a degree of confidence, and as such it can inform professional judgement. Ultimately, of course, it is just one form of evidence, albeit the most useful available, and needs to be used alongside other landscape scale evidence, such as soil types, geology, hydrology, etc.; the HLC/geology/soils model for enclosures shows how some of these forms of evidence can be combined into a single model (section 10.6).

14.4 Inherent risks

14.4.1 Archaeology in the low probability zone

There are two obvious risks inherent in the use of predictive models. First is the danger that the low probability zone is written off in terms of heritage protection, so careful judgement is needed to inform advice given on a case by case basis. One factor to be considered is proximity to the high probability zone. As an example, it is worth looking at the Penwith enclosures model (Lowland Cornwall Volume 4, section 11.2.7). Fourteen enclosures are captured in the low probability zone of this model. However, only three of these are more than 300m away from land in the very high probability zone, eight are less than 100m from the very high probability zone and four of these are within 50 metres. That closest to the very high probability zone is the very small oval enclosure at Higher Cargease, Ludgvan (Fig 52). The enclosure is located in a field which was rough ground in the 1840 and 1880 time-slices and was enclosed in the twentieth century. Given the close proximity of five other enclosures and field boundaries shown here from NMP mapping, there is obviously a high potential for below-ground archaeological material to survive in the fields to the south and west of Higher Cargease (and probably those to the north also), regardless of the fact that they are classed as part of the low probability zone. In this case, if a development such as the installation of a wind turbine in these fields were to be proposed, the planners should be advised that some form of mitigation would be required.

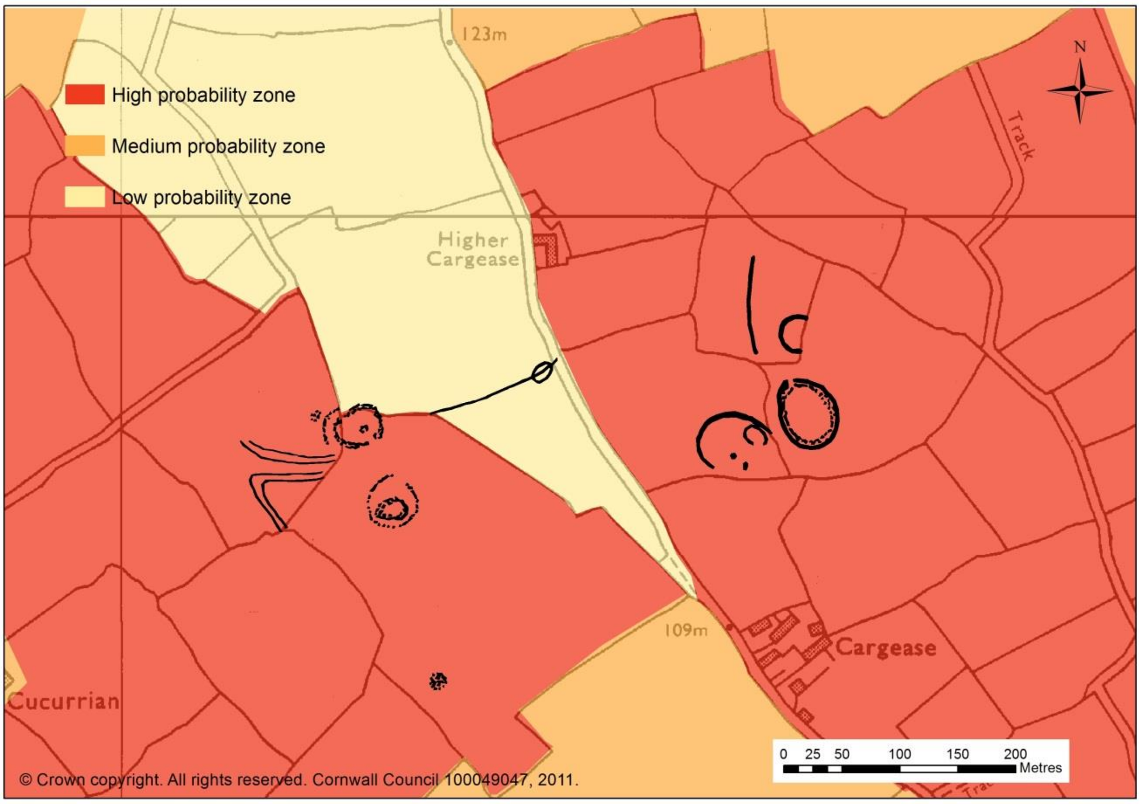

Fig 52. NMP mapping of enclosures and other features at Cargease, Ludgvan.

One way in which the models could be optimised to minimise this risk would be by generating a buffer around the very high or high probability zones. To see what effect this might have, two buffers were generated around the very high probability zone of the all enclosures model, one set at 50m and the other at 100m. The 100m buffer captured an additional 38 enclosures and the 50m buffer captured 22. A point of interest arising from this is, given that settlements would be sited to provide maximum access to variable resources, it follows that they would tend to be located at the boundaries between different landscape zones. However, a manual count of all enclosures situated either within the 100m buffer or within the very high probability zone but 100m or less from its edge showed that only 45% were within this 'edge zone'. Nonetheless the question of increased density of settlement around the edges of the various HLC Types is worthy of more detailed future research.

14.4.2 The self-fulfilling prophecy

The second equally serious risk is that archaeological investigation is focused on the high probability zone to such an extent that over time the model becomes a self-fulfilling prophecy, and the full potential of land in the low probability zone is never recognised. This will have implications for archaeological research as well as for cultural resource management. However, this situation does not appear to have been reached in Cornwall, despite HLC being used to advise planners since the late 1990s. Analysis of the Events Record carried out as part of this project shows that of the 5,678ha surveyed by the Events, 2,873ha are within AEL. This is 50.6% of the total area surveyed. Taking Lowland Cornwall as a whole, AEL covers 55% of the total area. So this indicates that the Events are not focused particularly on AEL, because if that were the case the percentage of the area surveyed would exceed 55%. However, since this analysis there has been a considerable amount of mitigation work carried out around the edges of towns and villages (land around Newquay is the most extensive case) mostly in land classed as AEL, so this situation may have changed. It would be instructive to obtain more up to date statistics from the Events Record and to monitor the Events, possibly on an annual basis. To obviate both these risks the predictive models should be seen as broad brush guides rather than as a predetermined set of rules, and curatorial archaeologists need to exercise a degree of flexibility in their application.

14.5 Potential for future work in Cornwall

Since the completion of the Lowland Cornwall HLC mapping further refinement along similar lines has been carried out with the result that the whole of West Penwith now has an HLC containing Sub-Types and multiple time-slices. While on one level it would be desirable to complete this exercise over the whole county, given the amount of time this would require a more cost effective use of resources might be to review the current 1994 HLC: in particular to distinguish between Farmland C20 which is former rough ground and that which is altered AEL, but also to identify and correct the unquantified number of errors in the 1994 HLC made due to the rapid mapping techniques used at the time.

Another useful exercise would be to carry out testing of some of the models by programmes of geophysical survey. This would be best focused on the low probability zones because for any one site encountered in the low probability zone a disproportionate number of sites would have to be encountered in the high or medium probability zones for the model to remain stable. So, for instance, if there is a three times higher chance of encountering a site in a model's high probability zone than in the low, then the test should survey an area of low probability three times larger than the area of high probability.

14.6 Applying the models elsewhere in England

One of the aspirations of the Lowland Cornwall project was that the methodology for creating the models might be applicable to other counties. In principle this should be the case although there are grounds for expecting that the application will require some adaptation elsewhere.

1. In some counties there has been widespread recent landscape change which has obscured or removed elements of the historic landscape, making it more difficult to read than the Cornish landscape, whose historical depth is plainly evident in many places.
2. For most of Cornwall early place-name evidence is central to the idea of perpetuation of the settlement zone from the Romano-British period to the early medieval. This type of evidence may not be available to the same extent in other counties, making it more difficult to identify, although Anglo Saxon settlement names could be as old as the *tref* place-names. This aspect of the approach will clearly require adaptation to the available evidence base in other areas.
3. HLC methodology varies from one county to another so it is not easy to make direct comparisons with the 1994 Cornwall HLC, nor with the Lowland Cornwall HLC. The approach may easier to apply and validate in areas already benefiting from an attribute-based HLC and with a more developed form of HLC terminology.

14.6.1 Lessons learnt

The SMR data which formed the project's key dataset had to undergo an initial filtering process in order to remove multi-indexed records. No suitable automatic data verification software was available to the project at the time so the filtering had to be done manually. For similar projects in the future this would be better achieved using an automated system.

Whilst acknowledging that it is not wholly comprehensive, the large size of the SMR dataset makes it suitable for predictive modelling. However, there are some weaknesses in the data:

- Inconsistencies in the way sites have been recorded
- Site identification is sometimes based on interpretation rather than certainty
- Sites identified from cropmarks are done so with varying degrees of confidence but all were treated as *bona fide* sites in the high level models

Given this, it is possible that a degree of error crept into some of the models. Nonetheless it remains true that the dataset constitutes a large body of information the vast majority of which is accurate and reliable. Similar projects in the future might consider more comprehensive quality assurance of the dataset and implementing a probabilistic sampling programme for model testing.

To some extent these issues were addressed when creating models for the four study areas by using the confidence field (validity) used for sites mapped during Cornwall's NMP. There still remained a considerable number of sites whose veracity was unqualified, but for other counties with SMRs which include a confidence field this would not be an issue.

There were also issues with the 1994 HLC which was carried out rapidly at 1:50,000 scale. This inevitably led to errors which will have crept into some of the models. Again for counties with more recent HLCs this would not be an issue.

The models based on the Kj parameters are simple in concept and straightforward to build, although a degree of expertise in Excel is required when creating the templates in which the models are run.

The project demonstrated that using Dutch techniques, predictive models can be successfully made using HLC Types, HLC Sub-Types, bedrock geology, soil types or combinations of these as variables.

Agricultural Land Classification data proved too generalised and schematic to build meaningful models and the Landuse models were generally unsuccessful, most likely reflecting the difficulty of accurately defining polygons for each Landuse class.

For the most part it was possible to create models with three probability zones, but in some cases it was only practicable to produce two-zone (site/no site) models.

All the models made during the project favoured accuracy over precision, the aim being for the high probability zones to capture 70% or more of the sites, although in a few cases this was not possible. This is important if the models are to be used for planning purposes.

The prioritising of accuracy over precision influenced decisions on how to define the cut-off points between the probability zones. For the most part the cut-off points were defined at the point when the Kj values stopped increasing. In some cases, however the Kj values continued to increase after the point where the Relative Gain measures began to fall. In these instances a decision had to be made as to which measure to use; occasionally, better performing models were made by using the Relative Gain measures to define the cut-off points rather than the Kj parameters.

In gauging model performance it is important to consider the relationship between all three zones rather than using Kvamme's gain to assess the performance solely of the high probability zone. This is achieved by measuring the ratio of the Indicative Values between the three zones: in a model that performs well there should be a considerably higher chance of encountering a site in the high probability zone than in the low.

Events Record data was used to test all the models, using both point data and area data. There were differences between the point and area test results in the majority of the tests, although the outcomes of the two tests were broadly similar in all cases. For the Lowland Cornwall project the Events polygons were redrawn based on field boundaries shown on current OS maps, and variations in average field size in each HLC Type resulted in the differences in the test results. It would be better for similar projects in the future to use the original Events polygons or only point data for testing purposes.

One of the intentions of the project was to produce models for sites based on area as well as point data. To this end the settlement polygons were created around groups of sites. Models were built for the polygons and were tested (Lowland Cornwall Volume 4 but not presented in this volume) but none of the models was satisfactory. In this instance the polygons were drawn manually. For similar projects where this is attempted it would be better for the polygons to be created by generating a buffer around the group of features – this would at least be less subject to the vagaries of human interpretation.

Although accurate and precise models for enclosures in each study area were made using all four time-slices, there were difficulties when trying to apply these models across all four study areas. Partly this was due to regional differences but also to the variations in size between the study areas. Similar projects would be more effective if the study areas were defined using OS grid tiles rather than by parishes as this would allow study areas of equal extent to be defined.

14.6.2 Specific examples

The observations below are made on the assumption that the starting point for models in other parts of the country is the same as for the Cornish models: namely that the medieval settlement and farming heartland corresponds to the zone of settlement and farming in the late prehistoric and Romano-British period. The point should be made, however, that the Lowland Cornwall methodology could equally be used to answer a range of similar questions or address comparable research or management needs.

While researching accessible HLC reports it was notable that all list potential applications of HLC, such as informing Conservation Area Appraisals, informing Higher

Level Stewardship agreements and advising on the impact of development on the historic landscape character. None list provision of development control advice in the predictive sense that Cornwall does. However, each HLC report identifies field types representing early agricultural enclosures (late medieval/early post medieval) which potentially correspond to Cornwall's Medieval Enclosed Land.

14.6.3 Devon

The most obvious example is Devon, and there are shared similarities between the HLC and, in places, the landscape in Devon and Cornwall. In Devon the early field types include:

- Medieval enclosures based on strip fields (type 26)
- Barton fields (type 21)
- Medieval enclosures (type 25)
- Post medieval enclosures with medieval elements (type 20)
- Medieval strip enclosures (type 27)
- Strip fields (type 23)

The report on NMP mapping of four discrete study areas in Devon included a rapid analysis of the range and number of sites mapped within each HLC Type (Young and Turner 2007). This concluded that:

- Of all the HLC types in the project area types 26 and 21 contain by far the most prehistoric/Romano-British enclosures
- Many of the site types which are rare in the project area, including ring ditches, long barrows, lynchets, and prehistoric field systems, are found mainly in type 21 and, to a lesser degree, in type 26
- Medieval-derived fields generally contain the largest numbers of recorded sites and the most diverse range of archaeological features.

NMP mapping suggested that the archaeological potential of Barton fields (type 21) is particularly high. In counties where such conclusions can be made, the Lowland Cornwall modelling approach could be successfully applied.

14.6.4 South Yorkshire

The report on the South Yorkshire HLC (Marchant *et al* 2013) contains a map showing a reconstruction of the medieval HLC, the equivalent of the Lowland Cornwall medieval time-slice. This indicates that there were large tracts of open moorland in the west of the region and wetland landscapes in the east (*ibid*, 694). The early enclosure takes the form of open field, strip enclosure and piecemeal enclosure of moorland or woodland. In each case the report notes that these types have the potential to contain evidence for buried archaeological remains. So here, too, it is possible that HLC models could be used to show those areas of high potential.

14.6.5 Buckinghamshire

The report on the Buckinghamshire HLC is useful in that it contains statements on archaeological potential for each HLC type (Buckinghamshire County Archaeological Service 2006). The forms of early enclosures are Co-axial Enclosures, Pre 18th Century Irregular Enclosure, Pre 18th Century Regular Enclosure, Pre 18th Century Sinuous Enclosure, Meadows, and Enclosed Furlongs and Strips. All these types have either high archaeological potential or medium/high. The Co-axial Enclosures may well be derived from prehistoric fields and so correspond to Cornwall's Prehistoric Enclosed Land, so again some modelling may be possible.

Elsewhere in Buckinghamshire there are two forms of Parliamentary Enclosure (enclosure between *c* 1738 – *c* 1860) whose archaeological potential is classed as medium: there are good examples of ridge and furrow and 20% of the area's deserted medieval villages, as well as buried remains of some pre-medieval sites. These fields can be considered to be the equivalent of Cornwall's Farmland C20 which is altered Medieval Enclosed Land rather than fields enclosed from Rough Ground. In fact the presence of ridge and furrow might be a more accurate indicator of the potential for buried prehistoric/Romano-British remains than field or HLC type.

14.6.6 Northamptonshire and Warwickshire

There are examples of cropmarks of prehistoric features formerly masked by extant ridge and furrow becoming visible once this has been levelled, for instance at Ecton and Faxton in Northamptonshire (Deegan and Foard 2008, figs 3.13 and 7.8, pp40 and 135). Interestingly the example at Faxton is used to demonstrate discontinuity between the prehistoric/Romano-British and medieval landscapes, but while the Iron Age or Roman features are on a quite different alignment to the ridge and furrow (showing discontinuity in pattern and layout) it actually demonstrates continuity of the settlement and farming zone. In Warwickshire recent work as part of the NMP has recorded the same phenomenon (Priest and Dickson 2013, 55, 58). The examples given there are Thornton enclosure, a double ditched oval enclosure thought to date to the Middle Iron Age, and a possibly Iron Age or Roman settlement northeast of Warmington.

In Warwickshire by recording many polygons as Medieval Open Fields in previous HLC Types the HLC project almost trebled the evidence for ridge and furrow compared with that contained in the HER (Wallace 2010). Early enclosure types containing ridge and furrow are Irregular (piecemeal) Enclosure, Floodplain and Meadows, and Paddocks and Closes, where the archaeological potential is either high or medium/high. As in Buckinghamshire later enclosure (in Warwickshire termed Planned Enclosure) also contains some areas of ridge and furrow and is classed as medium potential.

14.6.7 Hampshire

While the presence of ridge and furrow can be used at a simplistic level to define areas of high potential, in some counties this will not be possible. One aspect of Hampshire's medieval landscape (and that of the Wessex downlands generally), for instance, is the rarity of ridge and furrow on the chalk, where there are extensive prehistoric and Romano-British relict landscapes. A possible explanation is that in Hampshire the light, well-drained soils on the chalk did not require this type of cultivation (Hughes 1994). Here most of the prehistoric and Romano-British features are within areas of land subject to later enclosure, particularly Parliamentary type enclosure. However, in many places on the downs the levelled remains of underlying medieval field systems survive. In some places, such as in Tichborne parish and at Exton and Chalton, it is possible that the medieval fields are reusing earlier boundaries (Young 2011, 110 – 120). The most developed instance of this possible sequence is on Winnall Down where it is impossible from aerial photographic evidence alone to distinguish the medieval fields from those which are earlier in this particularly complex landscape (*ibid,* 116). In counties such as Hampshire using HLC Types as sole variables for creating models would not provide the complete picture, and NMP or SMR data would need to be used in conjunction with HLC.

In common with some other counties Hampshire has developed a series of Landscape Character Areas (LCAs). In defining the LCAs consideration was given to topography, geology, soil types, County Landscape Types, National Character Areas, experiential characteristics, biodiversity, archaeology and the built environment as well as historic character. As part of the Hampshire South Downs NMP project the NMP mapping within each LCA was analysed and in the great majority of cases the mapping was consistent with the LCA archaeology statements (Young 2011, 134-146). It may be that using LCAs in conjunction with HLC Types will produce better defined models than those made using just HLC Types. If new LCAs were developed in Cornwall (the current Historic Character Areas are not considered very useful and are little consulted) these could be used to refine the models. For instance, LCAs might better reflect regional differences between the four study areas, in particular the differences noted in Poundstock.

15 Discussion and conclusions

15.1 The high level models (1994 HLC)

Chi-Squared tests indicated that there is a statistically significant correlation between HLC Types and all of the relevant site types, apart from hillforts. They also showed that there are significant correlations between these site types and soils, bedrock geology and Agricultural Land classes.

Broadly speaking the high level models fell into two categories, their high probability zones formed by the following Types:

1. Farmland Medieval, Farmland Prehistoric and Farmland C20
2. Farmland Prehistoric, Farmland Post Medieval, Farmland C20 and Coastal and Upland Rough Ground

The first captures enclosures and early medieval settlements; the second open settlements, barrows and find spots. The field systems model is a 'hybrid' of the two, its high probability zone being formed by a combination of Farmland Medieval, Farmland Prehistoric, Farmland C20 and Coastal and Upland Rough Ground.

Despite some inherent weaknesses, Events Record data provided a useful sample to validate and test the models, using either all Records as an internal validation sample or new sites only as an independent test sample. The enclosures model was validated by both samples as was the field systems model (although not as clearly when the test was based on area rather than points). The barrows model was validated by the internal sample but rejected by the independent sample, but because this sample consisted of only 11 sites it cannot be regarded as conclusive. The open settlements model was also rejected.

It is very likely that the models are influenced by the form of monument survival. Extant sites are more numerous in Rough Ground and Recently Enclosed Land, and the barrows and open settlement datasets are characterised by large numbers of extant sites; some extant field systems spread beyond enclosed land into Rough Ground. So to a degree the category 2 models are retrodictive, indicating where known extant sites are recorded rather than where unrecorded sites are likely to be located. When the open settlements in the Events Record sample were used to test the enclosures model the model was validated. This suggests that the open settlements model is indeed retrodictive and that the distribution of previously unrecorded open settlements is most likely to replicate that of enclosures. In a similar vein, when a model was built for cropmark field systems its high probability zone was formed by Farmland Medieval, Farmland Prehistoric and Farmland C20, again indicating that the distribution of unrecorded field systems is likely to replicate that of the enclosures.

As a whole the models indicate that the HLC Types Farmland Medieval, Farmland Prehistoric and parts of Farmland C20 do correspond with the later prehistoric/Romano-British settlement and farming heartland. These three Types made up the high probability zone of the enclosures model and by inference, the open settlements model, as well as that of the cropmark field systems model. Farmland Medieval and Farmland Prehistoric were the two highest-ranked Types in the early medieval settlement model, corroborating the suggestion that the later prehistoric/Romano-British settlement zone was perpetuated into that period.

The barrows model was less clear-cut. The HLC Type Farmland Medieval contained more barrows than any other but was ranked in the model's medium probability zone. It is probably most accurate to say that there is more chance of previously unrecorded barrows being found in Farmland Post Medieval and Farmland C20 than other HLC Types, but that considerable numbers also will be located in Farmland Medieval.

The models for find spots all had high and low probability zones only and it is more than likely that the data held in the SMR is not representative of the true distribution of prehistoric finds in lowland Cornwall; rather that it reflects the areas of activity of a few finds collectors. Systematic programmes of field walking in the future may help to redress this bias.

In order to judge to what extent the distribution of cropmarks might represent the high probability zone for previously unrecorded below-ground archaeological remains, a cropmark visibility model was created by combining SMR cropmark records with soil types, bedrock geology and CAU reconnaissance flight patterns. Although the resulting model appeared accurate and reasonably precise, when tested with the independent sample from the Events Record it was rejected. This model indicates where cropmarks are most likely to be visible rather than where below-ground archaeology is most likely to be found. Whilst the model has, therefore, no great value as a predictive modelling tool, it should nonetheless prove useful for research purposes.

One implication of the result of the cropmark visibility model is that cropmark distribution might be influencing the other models. To assess the extent of this influence models were made for enclosures using soil types and geology as variables and then combining these with HLC Types to produce a model taking all these variables into account.

A significant result of the enclosures/soil types model was the contrasting number of enclosures recorded from areas overlain by Denbigh 1 and Denbigh 2 soils. Both soil types are fertile loams which readily produce cropmarks but their distribution in Cornwall is markedly different: Denbigh 2 soils are found mainly in central Cornwall while Denbigh 1 types are confined mainly to the east. Analysis of enclosure distribution indicates that there is twice the chance of encountering an enclosure in areas of Denbigh 2 soils than areas of Denbigh 1. This suggests a genuine regional pattern to the distribution of enclosures, with fewer in eastern areas.

The final model which used soil types, geology and HLC Types as variables can be considered the definitive enclosures model produced during this phase of the project, although it is not as accurate as the model based solely on HLC Types, capturing 66% of the enclosures in its high probability zone as opposed to 79%.

15.2 HLC deepening

The four study areas chosen for HLC deepening are widely dispersed in different parts of the county and have differing underlying bedrock geology and soil types. Even so there were only limited differences in HLC between the study areas. The principal one was that in Enclosed Land the average field size is notably smaller in the Penwith study area than elsewhere and less than half the average field size in the Probus study area.

There are two notable similarities between all four areas. Firstly that the extent of Rough Ground has diminished significantly over time, having shrunk by 83% from 88.4 sq km in the medieval time-slice to 15.1 sq km in the 2011 time-slice. This former Rough Ground is classed as Post-Medieval, Early Modern or Modern Enclosed Land in the 2011 time-slice.

Secondly, Medieval Enclosed Land has undergone significant change over time, with land derived from cropping units in the medieval time-slice being extensively sub-divided into small rectilinear fields by the time of the 1840 time-slice. By the 2011 time-slice most of the sub-dividing boundaries had been removed and many fields derived from cropping units had been amalgamated into a smaller number of larger fields. In fact the alteration over time of fields derived from cropping units is more extensive than the loss of Rough Ground: 86% of fields classed as derived from cropping units in the medieval time-slice had been altered in some way by the time of the 2011 time-slice, mostly through amalgamation. These factors are clear in all four study areas, so can be taken to represent a countywide pattern. What is uncertain is whether the subdivision of fields had reached its peak by 1840 or whether the phase of removing subdividing boundaries had already started by then. Nor is it clear what the driving force behind subdivision on this scale was. It is suggested above (section 11.7.6) that in the parish of St Newlyn East subdivision might be due to a rise in population resulting from the success of mines in the area. However this fails to explain why there is the same level of subdivision in the Poundstock study area where there were no mines in the vicinity.

There are some differences between the 1994 and Lowland Cornwall HLC Type interpretations. The most obvious is that more than 40% of the Penwith study area was classed as Prehistoric Enclosed Land in the 1994 HLC but only 7.5% in the Lowland Cornwall HLC. The view of the Lowland Cornwall HLC mapper was that much of the Prehistoric Enclosed Land had been altered to such a degree that its character was closer to medieval than the surviving prehistoric character found elsewhere, so it was reinterpreted as Medieval Enclosed Land. On the other hand the Lowland Cornwall HLC did identify small areas of Prehistoric Enclosed Land in Perranuthnoe and Marazion parishes, beyond its previously recognised extent.

Another difference is the much smaller area of Post-Medieval Enclosed Land in the Lowland Cornwall HLC compared with that of 1994. Some was reinterpreted as Early Modern Enclosed or as Modern Enclosed Land, but almost twice as much was reinterpreted as Medieval Enclosed Land. This may reflect the subjective nature of HLC interpretation, but more likely it is because the finer granularity of the Lowland Cornwall HLC meant that much more time was spent interpreting the landscape than was possible during the mapping of the 1994 HLC, which was carried out very rapidly at a broad scale. In instances such as this the Lowland Cornwall HLC should be seen as the more accurate.

15.3 The fine grained models (Lowland Cornwall HLC)

15.3.1 Landuse attributes

Models based on the Lowland Cornwall HLC were made using the early medieval Landuse attributes as well as HLC Types and Sub-Types. None of the models using the Landuse attributes were entirely satisfactory. This is probably because of the difficulty of accurately defining the true extent of the holding belonging to an individual settlement. The enclosures produced two-zone Landuse models which lacked precision. The high probability zones of the models for Probus, Penwith and Pelynt (and for all four study areas combined) were formed by the Core and 'Tidal' zones. In Poundstock the high probability zone was formed by the 'Tidal' and Marginal zones, and the enclosures here show a by-chance distribution.

When tested using partial data the only close fit was achieved when the Pelynt enclosures were tested using data from Probus, Penwith and Poundstock. The worst result was the Poundstock study area when tested using data from Probus, Penwith and Pelynt: the Marginal zone captured more than twice the predicted number of enclosures. In Penwith the 'Tidal' and Marginal zones performed better than predicted at the expense of the Core. Overall the Marginal zone does appear to be the zone of low probability but there is little distinction between the Core and 'Tidal' zones which appear to be more or less interchangeable across much of lowland Cornwall.

The models for barrows are inconsistent in that the order in which the Landuse zones are ranked is different in all four study areas. Probus appears to have an exponential influence on the model for all barrows, in which the Marginal zone is ranked highest, Core second and 'Tidal' third, as is also the case for the Probus model. The Marginal zone is also ranked highest in Poundstock but in both Penwith and Pelynt the Core zone is ranked highest and in Pelynt the Marginal zone is ranked third. The siting of clusters of barrows on prominent locations on high ground, which is a notable feature of barrow distribution in both Probus and Poundstock study areas, acts as a significant factor in determining the high probability zones of the models. Such locations are, for the most part classed as Marginal. Away from these Marginal locations there seems to be no obvious pattern – in Penwith, for example, there appears to be a by-chance distribution, with the barrows relatively evenly distributed between the three Landuse zones.

15.3.2 HLC Types and Sub-Types

The Lowland Cornwall HLC Types produced models for the enclosures that performed better in each of the study areas than the model based on the 1994 HLC. On the whole the high probability zones were more accurate and more precise, although in the Poundstock study area the models in some time-slices suggested a by-chance distribution. A common factor across all four study areas was that the highest-ranked Type was Medieval Enclosed Land.

More precise models were attained when HLC Sub-Types were used as variables. The predominance of Medieval Enclosed Land in the high probability zone was evident in the model for all the enclosures, which was formed of three Medieval Enclosed Sub-Types and one Prehistoric Enclosed Sub-Type. The high probability zone of the enclosures models for the Probus study area were all made up exclusively of Medieval Enclosed Land Sub-Types, but in all three other study areas the high probability zones also included Rough Ground or more recently enclosed land Sub-Types (albeit ranked below the Medieval Enclosed Sub-Types).

There were differences between the models for all enclosures and those for only the high validity enclosures in both Poundstock and Penwith study areas. In Penwith just under 90% of high validity enclosures are located in Prehistoric or Medieval Enclosed Land, whereas the corresponding figure for the other enclosures is only 67%. In Poundstock the make-up of the high probability zones of the all enclosures and high validity enclosures are in some cases significantly different. Another feature of the Poundstock models is that there are considerable differences in the make-up of the high probability zones from time-slice to time-slice.

The most precise models were those in which combinations of Sub-Types across all time-slices were used as variables. The very high probability zone of the model for all enclosures captured 74% of the enclosures in 40% of the project area, achieving a Kvamme's Gain of 0.465. When this model was applied to each of the study areas it proved a close fit or a reasonably close fit in all except Poundstock, where less than 70% of enclosures were captured in the very high probability zone and a much higher proportion were captured in the low probability zone than in any of the other study areas.

Similar models were made for each study area and their very high probability zones all achieved very high levels of accuracy and reasonable to good levels of precision. However, when tests were carried out using partial data (models from a combination of three study areas applied to the fourth), only in Pelynt was the test conclusively successful. In the other three study areas fewer enclosures than predicted were captured in the very high probability zone: Poundstock produced the weakest result with only half the predicted number of enclosures captured.

Further tests were carried out by creating two test samples consisting of roughly 30 sq km of land from each study area in an attempt to neutralize the possible bias resulting from regional and size differences between the study areas. Neither test was successful so it can be concluded that although combinations of Sub-Types from all time-slices enable accurate and precise very high probability zones to be defined for each study area, it is not possible to apply these to the other study areas. By contrast the overall high probability zones of these models, formed by Medieval and Prehistoric Enclosed Land, were validated by the tests, demonstrating that at a high broad brush level the HLC Sub-Type models can be successfully applied across the county.

On the whole the Lowland Cornwall HLC models for barrows perform better than the 1994 model. All are more accurate and in the Poundstock and Probus study areas the models are more precise. There are differences, however, in the make-up of the high probability zones between the study areas. Those in Probus and Poundstock are dominated by Recently Enclosed Land Sub-Types and Rough Ground; in Pelynt they are formed by Medieval Enclosed Land and in Penwith there is no clear pattern.

One issue in some of the barrow models is that more barrows are recorded from Medieval Enclosed Land than any other Type, but this is ranked in the medium probability zone of the Poundstock and Probus models. In the model for all the barrows across the Lowland Cornwall project area a number of Medieval Enclosed Land Sub-Types are included in the high probability zone, including MD Altered field patterns (Amalgamated) which captures more than twice the number of barrows than any other. The result is that the model is problematic, in that there is no clear pattern or predictive capability to the high probability zone, it being formed by Modern, Early Modern, Post-Medieval, Medieval and Prehistoric Enclosed Land Sub-Types as well as Rough Ground. It appears that in the future new barrows will most likely be found in Modern, Early Modern and Post-Medieval Enclosed Land but that considerable numbers will also be found in Medieval Enclosed Land.

15.4 Conclusions

The project has developed a better understanding of the extent and character of the prehistoric and Romano-British landscape of lowland Cornwall through analysis of the form and spatial distribution of enclosures and related features interpreted as dating to these periods. The analysis showed:

- That the enclosures are most often recorded with other features and in some places there are concentrations of enclosures and associated features, demonstrating that in favourable locations there was considerable density and continuity of occupation in the prehistoric and Romano-British periods.
- That the field systems are in the main very fragmented, and it is likely that only the major field boundaries produce clear cropmarks and that sub-dividing boundaries do exist but are not visible. There are hints that some of the fields in the Probus study area are on a coaxial arrangement and that the small brick-shaped fields characteristic of the West Penwith uplands did extend into lowland areas of the Penwith study area.
- That there are notable clusters of barrows, including 19 groupings or 'cemeteries'. These are often located on high ground in prominent positions in the landscape. Elsewhere the barrows are loosely distributed throughout the study areas and many are recorded singly, apparently in isolation.

The project succeeded in better defining the extent of Anciently Enclosed Land and Recently Enclosed Land HLC Types. It also showed that the process of reassessing some Types allowed more accurate analysis to be undertaken. For instance, HLC deepening showed that the extent of Rough Ground has diminished significantly over time in all four study areas and that Medieval Enclosed Land has undergone significant change over time, with formerly larger fields being extensively sub-divided into smaller units by the time of the 1840 time-slice, but that by the 2011 time-slice most of the sub-dividing boundaries had been removed. Also, some fragments of fields fossilising the prehistoric field pattern were identified in areas beyond their previously recognised distribution.

The models for enclosures and field systems support the suggestion that the medieval settlement heartland was also the prehistoric and Romano-British settlement heartland, at least at a broad brush level. This is the case both for models based on the 1994 HLC and the Lowland Cornwall HLC. Generally the Lowland Cornwall HLC models performed better than those based on the 1994 HLC, especially when using Sub-Types as variables.

The models based on bedrock geology and soils for cropmarks and also enclosures show that central and west Cornwall are the areas of high potential whilst proportionately far fewer sites are located in east Cornwall.

The models developed during the project will better inform both development control and management and land use decisions in lowland Cornwall by highlighting those areas with high archaeological potential. If developments are proposed in these areas, the models can be used to strengthen the case for archaeological mitigation. By the same token the areas with high potential can be seen as higher priority in terms of targeting landscape management initiatives.

On a strategic level the better understanding and predictive modelling resulting from the project will provide a more meaningful context in which to specify the scope of future development-funded archaeological recording and to assess the results of such work by analysis of how well the results fit the models.

Overall, the models using Dutch predictive modelling techniques are simple in concept and straightforward to build and run. Taking on board some of the lessons learnt from the Lowland Cornwall project, and with adaptations to take account of local conditions, the methodology could be applied elsewhere in the country, especially in counties where there is an attribute based HLC.

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Appendix 1: Summary of the 1994 HLC Types

Ancient Woodland

The remnants of traditionally managed woodlands, usually found in the steep-sided valleys extending inland from creeks or coves, in some cases via tributaries. Many of the ancient woods have been replanted in the later twentieth century with conifers. The slopes of the steep-sided valleys that also contain woodlands have relatively little ancient enclosure. Roads either run along the tops or bottoms of these valleys or cross them by zigzagging routes with fords (now usually bridges). Settlements are usually confined to their floors and most relate to either routeways or to processing industries (mills etc.).

Communications

Mass transportation links that are significant enough in scale to impact on HLC. The history and archaeology of the type is varied, but communications infrastructure, both large in scale and significant in visual and physical impact, developed largely in the twentieth century. Certain roads, however, date to the late medieval period at least, while airfields are the most recent development. Disused routes and areas which continue to have a significant impact on the landscape are also included. Due to its association with the movement of people and resources Communications HLC is found across all the study areas but in total forms a very small part of Cornwall.

Dunes

Dunes consist of successive ridges of blown sand and shell deposits with differing levels of vegetation cover. Near to their seaward side the dunes are often dominated by marram grass but further inland the dune systems change, giving way to mixed plant communities of grassland and trees. There is a long history of human interference, with successive phases of land use and abandonment. The date and history of dune development varies; available evidence suggests that the dune systems on the south Cornish coast are more recent than those on the north coast, although even these continued to develop well into post medieval times.

Farmland: C20

Enclosures of modern (1900-present) character. Principally landscapes of medieval origin whose field systems have been substantially altered by large-scale hedge/boundary removal in the 20th century but also re-organisation of post-medieval enclosures. It also includes, however, 20th century intakes from upland Rough Ground and woodland. The larger fields that result from hedge removal are often farmed more intensively, using heavier machinery, than in 'unimproved' medieval farmland.

Farmland: Medieval

Enclosures originating in the medieval period. The agricultural heartland, with farming settlements documented before the 17th century AD and curvilinear and sinuous field boundaries and patterns with either medieval or prehistoric origins (rather than the generally straight-sided fields of later enclosure; see post-medieval enclosures). Tends to be on relatively sheltered land, not too steep and not too poorly drained, but can extend onto the high downs. Networks of winding lanes and roads, often deeply cut by the passage of people, animals and vehicles over centuries or thousands of years. These connect farming settlements whose layouts are typically irregular, often clearly shrunken from hamlets; some are still hamlets. Churchtowns and a few larger villages are scattered through the Type which also contains most of the county's ancient towns.

Farmland: Post Medieval

Land enclosed in the 17th, 18th and 19th centuries, usually from medieval commons on what was previously Upland Rough Ground, so generally in relatively high, exposed or poorly-drained parts of the county. These include wholly new farms (usually around 30 acres, 12 hectares) with large regular fields, wholly new smallholdings, usually less than 5 acres (2 hectares) and extensions of or alterations to more ancient farms.

Fields usually have straight sides and boundaries have less mature or varied vegetation cover than in medieval farmland. Many are drystone walls. Being exposed, there is relatively little woodland compared with medieval farmland, but more evidence of its previous vegetation in gorse, heather, ling etc. on hedges and in corners of fields. Land is now usually pasture, with little arable, this being essentially marginal land.

Farmland: prehistoric

Land enclosed and farmed since late prehistory (probably Middle Bronze Age onwards, c1500 BC -). It often survives in marginal locations where surface rock is a problem, so that later improvement was too laborious and uneconomic. There are differences in attributes which probably reflect differences in date and later prehistoric reuse.

Areas of small field size, with very irregular and irregular field patterns, dominated by curvilinear and erratic boundaries probably originally date to the mid to Late Bronze Age (c1500- c700 BC). They are often associated with Bronze Age and Iron Age round houses (sometimes shown on OS maps), located on the edge of upland and coastal areas, in more windswept and exposed locations.

On more sheltered, less marginal ground (but probably still within areas of poorer than average fertility) there are blocks of small to medium sized, square and rectangular fields, arranged in regular field patterns, and dominated by gently curvilinear and sinuous, and occasionally erratic boundaries. These areas are probably the wholesale re-arrangement of Late Bronze Age enclosures, associated with later prehistoric farming hamlets, where field patterns and holdings had to be arranged in a more formal manner. The areas often have dominant linear boundaries, which are often parallel to the main orientation of local topography.

Industrial

Only extensive areas of industrialised land are placed in this Type, generally those over *c*10 hectares. Most will be the sites of extractive industry (mining and quarrying) and a. Where relict industrial landscapes have been overwhelmed by woodland or have become absorbed into upland Rough Ground, they are usually included in other relevant Types. The effect of these decisions is to significantly under-represent industry as most industrial sites are fairly confined and many derelict sites have been classified in other Types. The Type also records active industry and in certain areas this has continued on a significant scale; for example, the china clay industry on the Hensbarrow granite.

Military

Military complexes built or maintained in the twentieth century that are large in area. Those mapped as HLC are mostly still in active use, with only a few sites decommissioned. Individual sites can show considerable time-depth, used as defensive sites over successive periods, especially near important harbours. Cornwall's strategic location at the edge of the Atlantic has resulted in a wealth of military sites since the sixteenth century, with a marked peak in the Second World War. The vast majority of military complexes are now abandoned, and are not mapped as Military in the 2011 HLC; their principal impact is to add local time-depth in specific locations to other HLC Broad Types. Military activity can vary and the HLC is sub-divided on the basis of the type of built features, scale and location.

Ornamental

Ornamental HLC is land that has been carefully designed, manipulated, and managed to create an idealised landscape, associated with mansion houses and accompanying estates. A majority of Ornamental HLC in Cornwall was established in the eighteenth, nineteenth and very early twentieth centuries, often by individuals made wealthy by profits from copper and tin mines. Vestiges of medieval designed landscapes survive in the form of deer parks, but most only survive as components of time-depth within areas of other HLC. In the later twentieth century many areas of Ornamental HLC were converted back to Enclosed Land as the estates on which they were founded collapsed.

Plantation and scrub

Ancient Woodland was identified using the 1:10,000 habitat maps held by Cornwall Wildlife Trust. Once this had been distinguished, the remaining broadleaved wood was regarded as scrub and the conifers as plantation. These are treated as one Type but can normally be separated by the scrub being linear and the plantations being larger and block-shaped.

Recreational

This Type covers large areas of land given over to recreation, predominantly in the late twentieth century. Golf courses, however, were the earliest to be developed, with a handful founded at the close of the nineteenth century. Groups of early twentieth century summer houses were established close to many of the larger beaches, especially on the north coast, but most are now permanent settlements, and recorded as Settlement HLC. Other, smaller areas of recreational facilities are absorbed into other Types, again often as Settlement. Recreational HLC is predominantly found in close proximity to the coast, and in particular, close to settlements where the tourist industry forms a major part of the economy. Access by car now forms an important part of recreation

Settlement

Built-up areas from larger hamlets upwards. This is a complex Type with numerous historical trajectories contributing to its present form.

Most medieval towns in Cornwall were fairly evenly spaced (around 10 miles apart) and provided markets for agricultural hinterlands. Farmers in the study area would also have regularly resorted to Liskeard for the markets. These medieval towns were small, with just three or four main streets and small resident populations.

In the post-medieval period, the old towns grew slowly until the 18th and 19th centuries when increased mining activity led many to expand more rapidly.

Many rural settlements will have their origins in the Early Medieval period (i.e. post-Roman and pre-Norman), or even earlier, but most extant buildings (except churches) are post-medieval or modern. Lanes and open spaces within settlements may be medieval. Virtually all rural settlements large enough to be included in this Type have later 20th century housing at their edges.

Their long and complex histories have produced, in Cornish towns and villages, places with a wealth of historical and archaeological features. Clearly some settlements will be simpler than others, notably the post-medieval industrial villages but all will have a variety of building types, ages and styles, different sectors for residence, commerce, industry, storage, recreation, burial and ceremonial. Some will also have military remains (from late medieval castles to 20th century pillboxes). Most settlements will have rich subsurface remains with the footings of buildings and features of medieval or even earlier date.

Rough Ground

Rough Ground is defined by its rough vegetation and is predominantly found in agriculturally marginal locations (areas open to wind exposure, with poor soil fertility and drainage). Formed and maintained by human interference Rough Ground is 'semi-natural' and often demonstrates the longest continuous history of human utilisation. In part Rough Ground is the product of early prehistoric farming, and has been maintained through time by continued use for the seasonal grazing of livestock from late prehistory to the mid-nineteenth century. Once a crucial part of the agricultural economy, many areas of Rough Ground are now neglected, with vegetation levels at their highest since prehistory. The different HLC Types of Rough Ground are distinguished by their location: Upland Rough Ground - hilltop and upland plateau location; Coastal Rough Ground – coastal location.

Water

Water HLC is where bodies of inland fresh water dominate in scale. In Cornwall, most are man-made reservoirs dating to the later twentieth century. They often inundate important archaeological features (e.g. Siblyback Lake flooded medieval streamworks and field systems). Pumping stations, water treatment works etc. are usually associated with the reservoirs.

Those water features naturally formed also occur. These are most commonly located close to the coast, where bars have cut off former intertidal creeks from the sea. Dozmary Pool is the only large naturally-formed inland water body in Cornwall.

Appendix 2: 2011 HLC descriptions

Underlying the Lowland Cornwall HLC is a two to three-tier hierarchical system that increases in complexity with each tier. At the top, and most general, is the Broad Type; e.g. Rough Ground or Enclosed Land. Beneath, at the second-tier level, the complexity of attributes increases to further divide the Broad Type into HLC Type; e.g. Upland Rough Ground (undivided) or Medieval Enclosed Land. The third-tier has the most complex arrangement of attributes that can be identified from map-based evidence alone. In the Lowland Cornwall project third-tier HLC was sub-divided into different Sub-Types for Enclosed Land; for example:

Broad Type:	Enclosed Land
HLC Type:	Medieval Enclosed Land
HLC Sub-Type:	MD derived from Strip Fields (enclosed).

The following texts are descriptive and outline the details by which each HLC Type was identified and mapped in the 2011 time-slice.

Rough Ground

Rough Ground is defined by rough vegetation (typically variations of heath, coarse grassland, furze/gorse, and osiers/willow) and is predominantly found in agriculturally marginal locations (areas open to wind exposure, with poor soil fertility and drainage). It can include areas where exposed rock surfaces and rock debris also dominates.

It is sub-divided into the following HLC Types based on differences in location and land division; the differences also reflected in historic land use and ownership:

1. Upland Rough Ground (undivided)
2. Upland Rough Ground (divided)
3. Valley Rough Ground (undivided)
4. Valley Rough Ground (divided)
5. Coastal Rough Ground (undivided)
6. Coastal Rough Ground (divided)
7. Bare cliffs

HLC Types: Typical mapped attributes

(Based on recurring features found on modern OS 1:10,000 map data)

- **Common to all Rough Ground Type**s: rough vegetation mapped using standardised OS conventions.
- **Upland Rough Ground (undivided)**: hilltop and upland plateau location, open and not sub-divided.
- **Upland Rough Ground (divided):** hilltop and upland plateau location, sub-divided by boundaries into smaller parcels of land.
- **Valley Rough Ground (undivided):** valley bottom and valley side location, open and not sub-divided.
- **Valley Rough Ground (divided):** valley bottom and valley side location, sub-divided by boundaries into smaller parcels of land.
- **Coastal Rough Ground (undivided):** coastal location, open and not sub-divided.
- **Coastal Rough Ground (divided):** coastal location, sub-divided by boundaries into smaller parcels of land
- **Bare cliffs:** coastal location, large areas of exposed rock faces and rock debris, occasionally with areas of rough ground vegetation.

Enclosed Land

Enclosed Land is divided into field enclosures and sub-divided by field boundaries. It has been improved and maintained by farmers as productive farmland, dominated by a changing mixture of grassland (pasture) and cultivated crops (arable, root and green crops).

Map sources typically show Enclosed Land as 'clean-land' without the conventions for rough ground vegetation although small areas of coarser vegetation and rock outcrops are depicted within some fields.

The character of Enclosed Land varies enormously with great differences in time-depth. It has an extremely complex landscape history, often with periods of continuous use (and change) over hundreds, and sometimes thousands, of years, and in this respect the time-depth of Cornwall's Enclosed Land is unusual.

To reflect this time-depth the Broad Types have been sub-divided into the following HLC Types distinguished by differences in field pattern, field shape, and the line of internal field boundaries. Further supporting interpretative evidence was provided by the dating analysis of historic settlements.

1. Prehistoric Enclosed Land
2. Medieval Enclosed Land
3. Post-Medieval Enclosed Land
4. Early Modern Enclosed Land
5. Modern Enclosed Land

Each HLC Type has been further sub-divided on the basis of tenure, land use and change identifiable in the attribute sets. Historic maps (1840 Tithe and 1880 OS) were used to aid interpretation and to help quantify landscape change in the past 170 years.

Prehistoric Enclosed Land (c1500BC – AD409)

Land enclosed and farmed since late prehistory (probably Middle Bronze Age onwards, *c*1500 BC -). It often survives in marginal locations where surface rock is a problem, so that later improvement was too laborious and uneconomic. There are differences in attributes which probably reflect differences in date and later prehistoric reuse.

Areas of small field size, with very irregular and irregular field patterns, dominated by curvilinear and erratic boundaries probably originally date to the mid to Late Bronze Age (*c*1500- *c*700 BC). They are often associated with Bronze Age and Iron Age round houses (sometimes shown on OS maps), located on the edge of upland and coastal areas, in more windswept and exposed locations.

On more sheltered, less marginal ground (but probably still within areas of poorer than average fertility) there are blocks of small to medium sized, square and rectangular fields, arranged in regular field patterns, and dominated by gently curvilinear and sinuous, and occasionally erratic boundaries. These areas are probably the wholesale re-arrangement of Late Bronze Age enclosures, associated with later prehistoric farming hamlets, where field patterns and holdings had to be arranged in a more formal manner. The areas often have dominant linear boundaries, which are often parallel to the main orientation of local topography.

In many areas, especially parts of West Penwith, the Lizard plateau, the Carnmenellis granite and the upland fringes of Bodmin Moor, it can be readily seen that Prehistoric Enclosed Land was altered by the amalgamation of fields in the medieval period. The character in these areas, however, is still prehistoric. It is only where there has been substantial re-arrangement in the medieval period that earlier character has been completely lost.

Medieval Enclosed Land (AD 410 – 1539)

The agricultural heartland of Cornwall, it is associated with historic settlements documented before the sixteenth century, when the majority of the population still farmed the land. For the most part it is generally located on the best land, on the gentler slopes and in the most sheltered areas (Herring 2009).

In some areas of Cornwall, particularly West Penwith, parts of the Lizard, the Carnmenellis granite and the upland fringes of Bodmin Moor, it is plausible to suggest that much of the Medieval Enclosed Land, although largely medieval in character, probably derives from heavily altered prehistoric land (see above), with the main land divisions and defining boundaries essentially late prehistoric in pattern. However, this is difficult to distinguish from map evidence alone.

Elsewhere the results of archaeological excavation suggest that underlying much of the Medieval Enclosed Land are former field patterns originally enclosed in the prehistoric period. In these areas there was wholesale re-arrangement, probably in the early medieval and medieval periods, though the exact date is often unknown, with variation likely from area to area.

New enclosure would also have been undertaken in the medieval period. This is often hard to distinguish in HLC terms (based on map evidence alone), except in areas where ring-fences survive in the landscape, and a relative chronology can be established.

Originally, the majority of Medieval Enclosed Land was organised as open 'strip' field systems. The strips were groups of parallel, often sinuous, narrow, long, rectangular fields, open to each other, and divided from the next only by a low bank. Several similar-sized strips were arranged in a group or bundle, termed a 'cropping unit' by landscape historians in Cornwall. Several cropping units were open to one and another but grouped within a large 'open' field enclosed by a substantial stock-proof boundary. The systems were associated with farming hamlets where several tenant families lived, each tenant holding a certain amount of land, intermixed with other tenants within the system. There was a degree of communalism as the land was shared out equally amongst the tenants and the open fields grazed in common in the ley period.

<u>Medieval Strips (Unenclosed)</u>

Open strip field systems are now rare; and the Sub-Type MD Strips (Unenclosed) correspondingly so. Cornwall is fortunate to have one of the last survivals at Forrabury, Boscastle.

<u>Medieval derived from Strip Fields (Enclosed)</u>

Evidence in Cornwall suggests that open strip fields were enclosed from the fourteenth to seventeenth centuries. This was linked to broad changes in land tenure and economy whereby a tenant's land holdings were grouped together. The open strip systems appear to have been enclosed in two main ways, depending on the settlement history of a particular location.

Where hamlets of farming families continued the open strip systems could be enclosed as strips, more often as a small group of strips amalgamated together, and farmed by a single tenant. Instead of a low bank dividing these, a stock-proof boundary would be built; usually an earthen bank or Cornish hedge, with the boundary fossilising the earlier low bank that once divided the strips. This process resulted in the HLC Sub-Type, MD derived from Strip Fields (Enclosed).

<u>Medieval derived from Cropping Units</u>

Where farming settlements had changed from several families to a smaller group, or even individual families, strip systems would be enclosed on a larger scale, usually on a cropping unit by cropping unit basis. Each cropping unit would be enclosed to form an individual field, enclosed by a boundary such as an earthen bank or Cornish hedge, and farmed by a single tenant. Groups of enclosed cropping units arranged close to one another could then be farmed as a single holding rather than in an intermixed manner. This process resulted in the HLC Sub-Type, MD derived from Cropping Units.

Medieval peripheral fields

In the damper, heavier soils of the valley bottoms MD peripheral fields were often used as hay meadows, to produce valuable winter feed for livestock. Once the hay was cut in late summer, livestock would graze the remaining grass into the autumn. Due to their location, peripheral fields might also contain areas of coarser vegetation, for example, patches of rushes.

Due to a combination of its long history and its coverage of the best agricultural ground, Medieval Enclosed Land has undergone many successive phases of alteration due to changes in agriculture, economy and settlement. This is recorded in the Sub-Types MD Altered field patterns (Sub-Divided, Amalgamated or Re-arranged). The scale, speed and date of changes varied from parish by parish, and often a farm by farm basis.

Medieval Altered field patterns (Sub-Divided)

Sub-division often occurs near to settlements that have grown substantially; from single farms (including small-holdings) to hamlets and in particularly, surrounding villages that grew rapidly in the nineteenth century, for example, St Newlyn East. Changes in land use will also affect the level of subdivision; where market gardening has developed and more in recent times, where horse paddocks have been established.

Medieval Altered field patterns (Amalgamated)

Amalgamation of field enclosures is not purely a modern phenomenon. Barton farms or head manorial farms were an early focus, due to differences in tenure, land use, and capital available to invest in labour and technology. In the parish of Probus, the Amalgamation of cropping units into larger fields appears to date to the late medieval period onwards. Elsewhere, Amalgamation is later in date, probably dating to the eighteenth and nineteenth centuries, but primarily focussed again on larger holdings and more wealthy land owners. Modern farming methods have resulted in large-scale, widespread Amalgamation. Typically, the smaller, later boundaries that sub-divided the fields were removed first but in certain areas, for example, parts of Penwith, large areas of many small fields have been amalgamated into single large enclosures.

Medieval Altered field patterns (Re-arranged)

Re-arrangement is where there has been the comprehensive, wholesale realignment of field boundaries, or where there has been both considerable amalgamation of field enclosures and the realignment of certain field boundaries. This can occur where a large estate has been split up into several holdings, for example, the small farms created from the Trerice Estate, St Enoder, following the First World War.

Post-Medieval Enclosed Land (1540 – 1749)

Land enclosed from the late sixteenth century through to the mid-eighteenth, typically from Rough Ground. The fields are generally medium to small in size, enclosed and divided by straight boundaries, the land enclosed principally in three ways.

Post-Medieval Intakes

Intakes were often extensions to blocks of Medieval Enclosed Land enclosing more marginal land (rough ground) in the valley bottoms and the upland areas. They are generally medium sized fields, mostly regular in field pattern, though occasionally irregular where fitted into the topography. Early maps often show small patches of coarse vegetation within them, the full improvement process sometimes taking generations of work to complete. On occasion they can contain a sinuous boundary, perhaps the remnant of a later medieval outfield (a temporary field enclosed and cultivated on marginal ground for a short time when economic conditions allowed).

In this period new farms and new small-holdings were enclosed on a piecemeal basis, the two distinguished from each other in terms of field size and settlement patterns. Further supporting evidence provided by Historic Settlement data helps to distinguish post medieval settlements from those founded in the early modern period.

<u>Post-Medieval New Farms</u>

New farms have been defined as holdings over 5ha in size. They are often located in upland areas, on former Upland Rough Ground, typically shown on historic maps with a single dwelling and surrounding group of small farm buildings. Most often they have English place-names but in west Cornwall earlier examples continued to have Cornish place-names. Field size tends to be medium in area, but noticeably larger than small holdings, as they were enclosed by full time farmers.

<u>Post-Medieval New Smallholdings</u>

New small holdings were single cottage dwellings, with few or no small farm buildings. They are located in upland areas, on former Upland Rough Ground, and also on the edges of valley bottoms, on areas of Valley Rough Ground, and more occasionally, Woodland. Worked by a single family, on a part-time, subsistence basis, the fields are small in size, square or rectangular in shape, and often regular or very regular in pattern.

<u>Post-Medieval Altered fields</u>

Due to successive changes in technology, economy and settlement pattern, a majority of Post-Medieval Enclosed Land has undergone extensive phases of alteration, recorded in the Sub-Types as PM Altered field patterns (Sub-Divided, Amalgamated or Re-arranged). Alteration to Post-Medieval Enclosed Land has occurred due to similar processes to those highlighted in Medieval Enclosed Land above.

Early Modern Enclosed Land (1750 – 1899)

Land enclosed in the late eighteenth and nineteenth centuries, usually from Rough Ground or Valley Rough Ground. The character is similar to Post-Medieval Enclosed Land; dominated by straight boundaries, regular or very regular field patterns, and dispersed settlement of single dwellings and holdings. However, the process was undertaken more rapidly, on a larger, more organised scale, due to the massive increase in population following the Agricultural and Industrial Revolutions.

<u>Early Modern New Farms and Smallholdings</u>

Both new farms and new small holdings are similar in character to those in the post medieval period, though field size on New Farms might tend to be larger due to changes in farming technology (for example the use of draught horses). Sinuous field boundary elements could still be included where medieval outfield boundaries, or former pasture boundaries, were incorporated into the field patterns.

<u>Early Modern Intakes</u>

Intakes varied in size but could be larger in field size than those in the preceding period. This is due to advances in farming machinery, changes in agricultural thinking and practice, and the continued growth in markets for produce. They were often extensions from existing medieval and post-medieval farms.

<u>Early Modern Altered fields</u>

Due to modern changes in technology, economy and settlement pattern, most Early Modern Enclosed Land has undergone extensive phases of alteration, recorded in the Sub-Types as EMod Altered field patterns (Sub-Divided, Amalgamated or Re-arranged). In many areas, especially coastal and those surrounding large towns and villages, parcels of Early Modern Enclosed Land have now been built on, and recorded under the Settlement Broad Type. Alteration to Early Modern Enclosed Land has occurred due to the similar processes to those highlighted in Medieval Enclosed Land above.

Modern Enclosed Land (1900 - present)

Land enclosed in the twentieth century, usually from Upland Rough Ground or more occasionally, Valley Rough Ground. The character is similar to Post-Medieval Enclosed Land and Early Modern Enclosed Land; dominated by straight boundaries, regular or very regular field patterns, and dispersed settlement of single dwellings and holdings, often with large farm sheds and buildings.

<u>Modern Intakes</u>

A majority of Modern Enclosed Land is classified as Intakes, often at some distance from the farming settlement, enclosed from large tracts of former Upland Rough Ground. Field size is very large, and occasionally a large field barn or shed is built to store livestock, silage or haylage. Due to the widespread use of modern vehicle based machinery the fields are interconnected by straight trackways.

<u>Modern New Farms and Smallholdings</u>

Modern smallholdings and new farms are fewer in number and area than in the preceding post medieval and early modern periods.

HLC Types: Typical mapped attributes

(Based on recurring features found on modern OS 1:10,000 map data)

- **Common to all Enclosed Land HLC Types**: enclosed and sub-divided by field boundaries.
- **Prehistoric Enclosed Land**: generally irregular or very irregular field patterns, in some instances regular field patterns; erratic, curvilinear and sinuous internal boundaries; often small fields, except where altered; typically located in more marginal locations in areas where there is an abundance of rock, e.g. granitic uplands and coastal locations.
- **Medieval Enclosed Land:** generally regular or irregular field patterns; dominated by sinuous internal boundaries, but sometimes dog-leg and J-shaped, erratic where amalgamation has taken place, and occasionally S-shaped and curvilinear boundaries; fields can vary in size and shape, especially where there has been large scale alteration; typically located on the best agricultural land, on valley sides and sheltered locations, although can extend on to valley bottoms and the edge of high ground; associated with older settlements, often former farming hamlets with Cornish place-names (less so in east Cornwall); settlements connected by networks of irregular lanes and roads.
- **Post-Medieval Enclosed Land:** generally regular field patterns; dominated by straight internal boundaries; rectangular or square fields, medium to small in size; typically located in upland areas and valley bottoms; associated with more recent settlements, often individual farms and small cottages with English place-names, occasionally Cornish; or next to important and large existing farms; settlements often connected with fields by straight tracks and roads. Occasional sinuous boundary suggesting former medieval land use but as a marginal part of the landscape.
- **Early Modern Enclosed Land:** generally regular field patterns; dominated by straight internal boundaries; rectangular or square fields, large to small in size; typically located in upland areas and valley bottoms; associated with more recent settlements, often individual farms and small cottages with English place-names; settlements often connected with fields by straight tracks and roads. Occasional sinuous boundary suggesting former medieval land use but as a marginal part of the landscape.
- **Modern Enclosed Land:** generally regular field patterns; dominated by straight internal boundaries; rectangular or square fields, large or very large in size; typically located in upland areas; associated with more recent settlements, often

individual farms with a mixture of Cornish and English place-names; fields connected by straight tracks and roads.

Woodland

Woodland is dominated by deciduous or coniferous trees, or a variation of the two. Following the end of the last glacial period deciduous trees once covered most parts of Cornwall. However, by the medieval period woodland cover had been reduced to the marginal steep-sided valleys. Traditionally woodland was managed to maximise economic return. Non-native coniferous trees were introduced on a large scale from the late eighteenth century onwards, not only to improve profitability, but also for ornamental purposes, especially in the estates surrounding large houses. Further deciduous species were also introduced and by the nineteenth century Cornwall's woodlands were more varied in character than ever before. Woodland products were once economically important but many areas of Woodland now receive negligible management, although tree cover is at its greatest since the medieval period. The different HLC Types of Woodland are distinguished by tree species, land use and possible time-depth.

Woodland is where deciduous or coniferous tree cover dominates, or a combination of the two.

The character of the Type can be sub-divided into the following HLC Types distinguished by differences in species, time-depth, location, and the size and shape of the areas under tree cover.

1. Shelterbelt
2. Timber plantation
3. Woodland mixed
4. Deciduous Woodland
5. Ancient Semi-Natural Woodland

Historic maps (1840 Tithe and 1880 OS) are used as further source material to better establish the original date of the woodland cover.

HLC Types: Typical mapped attributes

(Based on recurring features found on modern OS 1:10,000 map data)

- **Shelterbelt**: narrow, linear alignment of trees; usually dominated by conifers; located in exposed areas to protect certain fields or settlements from the wind - within areas of Enclosed Land; predominantly Post-Medieval, Early Modern and Modern, due to their exposed location.
- **Timber plantation:** dominated by conifers; if older then generally medium in size favouring valley sides and bottoms; if modern, often very large in size, dissected by tracks, the largest found in upland locations.
- **Woodland Mixed:** medium to large areas of woodland; mixed coniferous and deciduous, with varied history often incorporating smaller plantations that have been abandoned; found on valley sides or bottoms.
- **Deciduous Woodland:** small to large areas of woodland, varied history, often incorporating recent regeneration of woodland on areas of former Rough Ground, especially Valley Rough Ground.

Industrial

Industrial HLC is where industrial land is extensive and dominant in character. Its defining attributes vary but can include a huge range of built and cut features which, when taken as a whole, are often significant in scale, both physically and visually. Cornwall has a notable industrial legacy. Its origin stretches back into late prehistory, reaching a heyday in the late nineteenth century when a rapid decline led to many industrial complexes being abandoned. The Type also records active industry and in certain areas this has continued on a significant scale; for example, the china clay industry on the Hensbarrow granite. Located anywhere where resources and infrastructure allows it is sub-divided into HLC Types by differences in the resource exploited, and the methods employed to do so.

Only extensive areas of industrialised land are mapped under the Industrial Type.

Where a relict industrial landscape has reverted to Woodland or Rough Ground, or in urban areas, incorporated within larger blocks of Settlement, the HLC will use the dominant Broad Type. This significantly reduces the extent of Industrial HLC in the 2011 time-slice. Modern, light industrial units are included in the Settlement Broad Type.

It can be distinguished into those areas that are still in active use, and those that are disused. It is sub-divided into HLC Types on the basis of the dominant industrial processes that were undertaken in the area, though in many areas there have been successive phases of metalliferous, non-metalliferous and processing industries creating a complex set of landscape features.

1. Extractive, metalliferous
2. Extractive, non-metalliferous
3. Processing

Historic maps (1840 Tithe and 1880 OS) are used as further source material to better establish the former extent of industrial areas.

HLC Types: Typical mapped attributes

(Based on recurring features found on modern OS 1:10,000 map data)

Active

- **Extractive, metalliferous:** none (2011).
- **Extractive, non-metalliferous:** non-shaft based; large scale, open extraction; quarried rock faces; bare and scrubby over waste heaps, with variable amounts of large stone waste; access roads; reservoirs and settling ponds; small ancillary buildings.
- **Processing:** often large buildings; chimneys; small to medium sized ancillary buildings; settling ponds, leats and sluices; railways; docks, quays, wharves, storage bins, cranes.

Non-active

- **Extractive, metalliferous:** shafts; shaft safety walls; bare and scrubbed over waste heaps; platforms; revetment walls; reservoirs; engine houses (often unroofed); headframe; storage bins; chimneys; flues; calciners; buddles; settling ponds; ancillary buildings, stamps, leats; OS maps sometimes preserve old mine names, typically 'Wheal', and more occasionally 'Consols' or 'Mine'.
- **Extractive, non-metalliferous:** large scale, open extraction pits and quarries; rock faces; roofless buildings/ruins; bare and grassed over waste heaps; scrubby vegetation; former roads and paths; cuttings and embankments of disused rail and tramways; empty settling ponds; OS maps sometimes preserve old mine names, typically 'Quarry', and more occasionally 'Pit', especially in the china clay areas.
- **Processing**: abandoned buildings and ruins often on the edge of settlements; chimneys; ruined, roofless ancillary buildings and offices; empty settling ponds; railway and tramway embankments, cuttings and bridges; abandoned docks,

quays, wharves, and storage bins; OS maps sometimes preserve old names, typically 'Harbour' and 'Dock(s)'.

Military

Military complexes built or maintained in the twentieth century that are large in area. Those mapped as HLC are mostly still in active use, with only a few sites decommissioned. Individual sites can show considerable time-depth, used as defensive sites over successive periods, especially near important harbours. Cornwall's strategic location at the edge of the Atlantic has resulted in a wealth of military sites since the sixteenth century, with a marked peak in the Second World War. The vast majority of military complexes are now abandoned, and are not mapped as Military in the 2011 HLC; their principal impact is to add local time-depth in specific locations to other HLC Broad Types. Military activity can vary and the HLC is sub-divided on the basis of the type of built features, scale and location.

The Broad Type covers military complexes used in the twentieth century that are extensive in area. Individual sites can show considerable time-depth, used as defensive sites over successive periods, especially near important harbours.

Many complexes are too limited in area to be mapped in this Broad Type; others have been considered to be secondary to more dominant HLC Broad Types, especially where they have been significantly altered following abandonment.

The Military HLC Broad Type has been sub-divided into HLC Types based on differences in military activity, built features and scale:

1. Military airfields
2. Barracks
3. Artillery complexes
4. Military communications

HLC Types: Typical mapped attributes

(Based on recurring features found on modern OS 1:10,000 map data)

- **Military airfields**: large, open area; if active, enclosed by a significant perimeter boundary; runways; dispersals/pens; observation towers; hangers; sheds; ancillary buildings; radar stations.
- **Barracks:** large, open area; if active, enclosed by a significant perimeter boundary; buildings, often arranged in formal rows; parade ground.
- **Artillery complexes:** small to medium sized open area, if active enclosed by a significant perimeter boundary; gun emplacements; small buildings.
- **Military communications:** small to medium sized open area; if active, enclosed by a significant perimeter boundary; radar beacons; masts; buildings; often in coastal and upland locations.

Ornamental

Ornamental HLC is land that has been carefully designed, manipulated, and managed to create an idealised landscape, associated with mansion houses and accompanying estates. A majority of Ornamental HLC in Cornwall was established in the eighteenth, nineteenth and very early twentieth centuries, often by individuals made wealthy by profits from copper and tin mines. Vestiges of medieval designed landscapes survive in the form of deer parks, but most only survive as components of time-depth within areas of other HLC. In the later twentieth century many areas of Ornamental HLC were converted back to Enclosed Land as the estates on which they were founded collapsed.

Ornamental HLC has been carefully designed, manipulated, and managed to create an idealised landscape, associated with mansion houses and accompanying estates.

They were (and occasionally can still be) private landscapes of recreation for the landowners who commissioned them, but away from the house and garden the deer parks, parkland and plantations often had (have) an economic role within the estate.

The Ornamental Broad Type can be sub-divided into HLC Types based on differences in location, size and shape, planting, tree cover, and the type of built features found within them:

1. Pleasure garden
2. Parkland
3. Plantation
4. Deer Park

HLC Types: Typical mapped attributes

(Based on recurring features found on modern OS 1:10,000 map data)

- **Pleasure garden:** small to medium sized in area; enclosed and often sub-divided; situated close to a mansion house; shrubs and trees; beds, terraces and walkways; ponds; lawns; summerhouses; glasshouses; pavilions.
- **Parkland:** large in area; often open but can be sub-divided into large fields; framed by plantations and occasionally ponds; sinuous and curving boundaries, occasionally straight; tree clumps and copses; drives and carriageways; seats; isolated buildings.
- **Plantation**: small to large in area; often surrounding a mansion house and/or to frame parkland, or control views into/from parkland; planted mixed coniferous and deciduous species; often recorded as 'Plantation' on OS maps.
- **Deer Park**: large in area; open; scattered isolated trees; framed by plantations; sinuous and curving boundaries, occasionally straight; tree clumps and copses; drives and carriageways; isolated buildings; recorded as Deer Park on OS map.

Recreational

Recreational HLC covers large areas of land given over to recreation, predominantly in the late twentieth century. It is found in greatest concentration close to the main tourist resorts on the coast, but can be found inland also. Subdivision is based on differences in activity, and often distinguished on map evidence by symbology alone.

This Broad Type covers large areas of land given over to recreation, predominantly in the late twentieth century, and therefore only recorded in the 2011 HLC time-slice. Golf courses, however, were the earliest to be developed, with a handful founded at the close of the nineteenth century.

Groups of early twentieth century summer houses were established close to many of the larger beaches, especially on the north coast, but most are now permanent settlements, and recorded as Settlement HLC. Other, smaller areas of recreational facilities are absorbed into other Broad Types, again often as Settlement.

Recreational HLC is predominantly found in close proximity to the coast, and in particular, close to settlements where the tourist industry forms a major part of the economy. Access by car now forms an important part of recreation.

Subdivision is based upon differences in the density of buildings and the areas of Recreational HLC are often distinguished on OS maps by map symbology alone.

1. Golf course
2. Campsite, chalet park, etc.
3. Theme Park

HLC Types: Typical mapped attributes

(Based on recurring features found on modern OS 1:10,000 map data)

- **Golf course:** large, open area; small to medium sized buildings close to a car park; driving range; often found in coastal locations or the edge of major towns; mapped on OS maps with a symbol.
- **Campsite, chalet park, etc:** high density of small rectangular buildings; complex network of small roads; medium sized ancillary buildings; sub-divided with straight boundaries; often in valley and coastal locations.
- **Theme Park:** irregular scatter of small to large sized buildings; large car park(s); mapped on OS map with name.

Settlement

Settlement HLC is where buildings dominate, the areas in Cornwall varying in size from a single farmstead through to a large town or small city. The buildings found within them are mostly permanent dwellings, but generally as a settlement increases in size and importance, so does the number of buildings associated with economic, industrial and recreational activity. Many of Cornwall's settlements were established in the early medieval and medieval periods but others have a more recent history, especially in the mining districts. Due to the massive rise in population and successive changes to the economy many show considerable time-depth. Differences in settlement size and layout are the basis by which Settlement HLC has been sub-divided.

Settlement HLC is defined as areas dominated by buildings. Predominantly these are permanent dwellings, but as the size of a settlement increases, the range and number of non-dwellings rises as well. Thus there is a corresponding rise in complexity with larger settlements offering a range of economic, industrial and recreational functions that smaller settlements cannot sustain.

Difference in settlement size is the main basis by which Settlement HLC has been sub-divided.

The HLC-Types Highway settlement, Terrace and Row differ slightly in their identification process. These were mapped to further demonstrate the complexity of rural settlement; to enable Lowland Cornwall to better understand landscape change. Their classification is based on layout; Highway settlement on location and Terrace and Row upon the differing arrangement of buildings. However, these were only recorded when settlement size was comparatively small (usually the 1840 and 1880 time-slices), many are now part of larger settlements where the Village or Town HLC Type can be used instead.

The following HLC Types were used;

1. Farmstead
2. Hamlet
3. Village
4. Town
5. Highway settlement
6. Terrace
7. Row

HLC Types: Typical mapped attributes

(Based on recurring features found on modern OS 1:10,000 map data)

- **Farmstead:** single dwelling; farm yard; surrounding farm buildings; nucleated settlement.

- **Hamlet:** multiple dwellings (15 or under); townplace; scatter of farm buildings; occasional church and/or chapel; nucleated, linear, or dispersed settlement.
- **Village:** multiple dwellings (15 – 250 approx.); occasional farm included on settlement edge; service buildings e.g. church and chapels, school, library, village hall, sports club, pub; small car park; occasional small industrial estate; nucleated, linear, or dispersed settlement.
- **Town:** multiple dwellings (approx. 250 and over); multiple service buildings and zones e.g. churches and chapels, schools and colleges, leisure centres, sports clubs, pubs, commercial streets, fire stations; car parks; industrial estates.
- **Highway settlement:** linear or dispersed arrangement of dwellings along road; small in size (hamlet or village level); often located close to prominent cross roads on A and B roads.
- **Terrace:** linear arrangement of conjoined dwellings; shared alignment of frontage; only recorded when in isolation.
- **Row:** linear arrangement of conjoined dwellings; staggered alignment of frontage; only recorded when in isolation.

Horticulture

Horticulture HLC is dominated by the crops of flowers, fruit, nuts, vegetables, and ornamental garden plants grown on a commercial basis as a cash crop. These are areas of intensive land use, where infrastructure has also been built to maximise yield. Cornwall benefits from an early growing season due to the influence of the Gulf Stream. Commercial scale horticulture is largely a recent phenomenon, except in the Tamar Valley were the industry was already important by the late eighteenth century. The development of the railway network in the late nineteenth century allowed horticulture to further develop in parts of Cornwall, especially close to the main line. Since the end of the Second World War, however, foreign imports have ensured its relative decline.

Areas identified as Horticulture HLC are where the landscape is dominated by the crops of flowers, fruit, nuts, vegetables, and ornamental garden plants grown on a commercial basis as a cash crop. These are often areas of intensive land use, where infrastructure has also been built to maximise yield i.e. glasshouses and buildings where crops are started and buildings where the crops are processed.

Vegetable crops of swede/turnip (Swedish turnip) and potatoes are also grown by many farmers, particularly in west Cornwall but the crops can be grown within Enclosed Land without the permanent infrastructure of glasshouses and nursery beds.

Horticulture Broad Type is located in areas of Enclosed Land, often Medieval Enclosed Land, close to the temperate influence of the ocean or large 'tidal' rivers, on south and east facing slopes sheltered from the southwest and northwest winds. The land is usually sub-divided to aid the management of crops.

The Broad Type can be sub-divided on the basis of the dominant cash crops grown, and the corresponding differences in infrastructure to do so.

1. Orchard
2. Market Garden

HLC Types: Typical mapped components

(Based on recurring features found on modern OS 1:10,000 map data)

- **Orchard:** regular arrangement of trees (there is an OS map convention for an orchard); small to medium sized, square or rectangular fields often created by the subdivision of existing Enclosed Land; predominantly straight boundaries for subdivision; small buildings to edge of fields; located in sheltered locations away from high ground; often close to a dwelling; occasional shelter belts of woodland.

- **Market Garden:** small to medium sized, square or rectangular fields often created by the subdivision of existing Enclosed Land; predominantly straight boundaries for subdivision; glasshouses and/or polytunnels; small buildings to edge of fields; often located in sheltered locations away from high ground; occasional large buildings for processing; occasional shelter belts of woodland.

Communications

Mass transportation links that are significant enough in scale to impact on HLC. The history and archaeology of the type is varied, but communications infrastructure, both large in scale and significant in visual and physical impact, developed largely in the twentieth century. Certain roads, however, date to the late medieval period at least, while airfields are the most recent development. Disused routes and areas which continue to have a significant impact on the landscape are also included. Due to its association with the movement of people and resources Communications HLC is found across all the study areas but in total forms a very small part of Cornwall.

Broad Type: Introduction

Mass transportation links that are significant in scale to impact on HLC. This Broad Type has been divided into the following HLC types:

1. Major roads
2. Railways
3. Airfields (non-military: commercial and private)
4. Canals

HLC Types: Typical mapped attributes

(Based on recurring features found on modern OS 1:10,000 map data)

- **Major roads:** roadway; cuttings; embankments; roundabouts; fly-overs; underpasses; tunnels; slip roads; lay-bys; services.
- **Railways:** railway track; stations; large, medium and small buildings; cuttings; embankments; bridges, viaducts, tunnels; sidings; goods yards.
- **Airfields:** runway; taxi strips; hangers; large car parks; observation towers; terminal and ancillary buildings.
- **Canals:** channels; embankments; cuttings; inclines; tow paths.

Dunes

Dunes consist of successive ridges of blown sand and shell deposits with differing levels of vegetation cover. Near to their seaward side the dunes are often dominated by marram grass but further inland the dune systems change, giving way to mixed plant communities of grassland and trees. There is a long history of human interference, with successive phases of land use and abandonment. The date and history of dune development varies; available evidence suggests that the dune systems on the south Cornish coast are more recent than those on the north coast, although even these continued to develop well into post medieval times.

Infrastructure

This Broad Type was developed for the Lowland Cornwall project with the aim to better understand more recent landscape change; in particular the development of twentieth century large-scale 'sub-urban' infrastructure located separately from settlements. It is associated with the management, dispersal and collection of power, waste and transportation at a large-scale, the result of the size, needs and demands of the modern population.

Reservoirs are mapped in the Water Broad Type and have earlier origins, with a few developed in the late nineteenth century.

The Infrastructure Broad Type is sub-divided on the basis of land use, the differences identified by annotation on modern 1:10,000 OS maps. The scale of each area can vary, and in more recent development landscaping to reduce the visual impact has become increasingly important.

It has been sub-divided into the following HLC Types;

1. Car Park (out of town schemes)
2. Water/Sewage works
3. Electricity sub-station
4. Recycling station
5. Refuse tip (public and commercial)

HLC Types: Typical mapped attributes

(Based on recurring features found on modern OS 1:10,000 map data)

- **Car Park:** large open area; network of access roads; embankments and terraces; located on the edge of major towns near to A roads (as park and ride).
- **Water/Sewage works:** series of large circular and rectangular tanks; small ancillary buildings; trackways; occasional enclosing bank as part of landscaping works; enclosed by a single boundary, often straight; modern OS 1:10,000 map notes 'sewage works'.
- **Electricity sub-station:** square or rectangular in area; enclosed by a single boundary, often straight; modern OS 1:10,000 map notes 'El Sub Sta' and the line of several pylons converging on site.
- **Recycling Station:** open area; access and exit points; modern OS 1:10,000 map notes 'Recycling Centre'.
- **Refuse tip (both public and commercial):** large unenclosed area; trackways; access road; landscaping – embankments, shelter belts of woodland.

Water

Water HLC is where bodies of inland fresh water dominate in scale. In Cornwall, most are man-made features dating to the later twentieth century, with the HLC Types distinguished by their history and intended use. Those naturally formed also occur. These are most commonly located close to the coast, where bars have cut off former intertidal creeks from the sea. Dozmary Pool is the only large naturally-formed inland water body in Cornwall.

Water HLC is where bodies of inland fresh water dominate in scale. In Cornwall, most are man-made features dating to the later twentieth century, but those that were naturally formed also occur and are distinguished as a separate HLC Type. The date of the natural features varies; some were formed after the glacial period, but a majority of natural lakes next to the coast were formed by the separation from the sea in later periods, but at various times. The man-made are sub-divided based on size and use.

1. Reservoirs
2. Fish farm
3. Artificial Lake
4. Natural Lake

HLC Types: Typical mapped attributes

(Based on recurring features found on modern OS 1:10,000 map data)

- **Reservoirs:** large, open areas of water (not closed reservoirs); dam; small ancillary buildings; often in upland locations.
- **Fish farm:** series of small ponds; ponds vary in size but usually regular in shape; valley bottom location.
- **Artificial Lake:** small to large in size; often irregular in shape; most frequently in valley bottom location; larger lakes associated with abandoned extraction pits.
- **Natural Lake:** medium to large in size, variable in shape; named on modern and historic maps, predominantly coastal locations.

Intertidal and mudflats

The Intertidal and mudflats Broad Type covers the area between Mean Low Water and Mean High Water, and extends into those areas slightly above and beneath them.

This includes areas frequently inundated with seawater above mean high water due to the action of spring tides and/or exposure to swell, and the creeks of water (permanently below mean low water) that extend inland.

Differences in water cover, vegetation, sediment type and the exposure of bedrock form the basis upon which the following HLC Types are determined;

1. Intertidal mudflats
2. Salt marsh
3. Inshore water
4. Beach
5. Rocky foreshore

HLC Types: Typical mapped attributes

(Based on recurring features found on modern OS 1:10,000 map data)

- **Intertidal mudflats:** exposed between Mean High Water and Mean Low Water; dissected by sinuous channels at Mean Low Water; mud convention on modern OS 1:10,000 maps (but can include small areas of sand and rock).
- **Saltmarsh:** above the line of Mean High Water; vegetated, saltmarsh conventions on modern OS 1:10,000 maps.
- **Inshore water:** permanent water (creeks); below Mean Low Water.
- **Beach:** above the line of Mean High Water; sand and shingle conventions on modern OS 1:10,000 maps.
- **Rocky foreshore:** above the line of Mean High Water; rock debris and exposed bedrock conventions on modern OS 1:10,000 maps.