



Lowland Cornwall: the Hidden Landscape Volume One

The high level models

Historic Environment Projects

Lowland Cornwall: the Hidden Landscape Volume One

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The views and recommendations expressed in this report are those of Historic Environment Projects and are presented in good faith on the basis of professional judgement and on information currently available.

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Abbreviations

AEL	Anciently Enclosed Land
CC	Cornwall Council
EH	English Heritage
GIS	Geographic Information System
HER	Cornwall and the Isles of Scilly Historic Environment Record
HE	Historic Environment, Cornwall Council
HLC	Historic Landscape Characterisation
NGR	National Grid Reference
NMP	National Mapping Programme
OD	Ordnance Datum
OS	Ordnance Survey
PRN	Primary Record Number in Cornwall HER
REL	Recently Enclosed Land

Summary

Cornwall's lowland areas probably have the highest archaeological potential in the county, 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 models produced by the project will better inform future management and land use decisions.

The project consisted of four stages: preparation of datasets and high level predictive models; deepening or refinement of Historic Landscape Characterisation (HLC); further analysis of the archaeological resource and the preparation of predictive models using the refined HLC; and the presentation of final results.

This report is the first of four volumes presenting the results of the Lowland Cornwall project.

During the first stage of the project, data for selected site types was extracted from the Cornwall HER and correlated with HLC Types in order to identify recurring distribution patterns and to create high level predictive models. This volume presents the outcome of this work, describing the methodology used to create the models, the results of the modelling and a discussion and set of conclusions drawn from this research. Volume 1 also outlines the background to, and scope of, the project.

Lowland Cornwall was defined in the project 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. In arriving at this definition and mapping the extent of the project area, a number of factors were considered, including height above sea level, habitat data held by the Cornwall Wildlife Trust, Agricultural Land Classification data and Cornwall's HLC. In total the project area covers 3,189.8 square kilometres and contains the full range of HLC Types. The Isles of Scilly were not included in the project area.

Data was then extracted from the Cornwall HER. This consisted of a range of site types of prehistoric or Romano-British date, including findspots, and also of early medieval date in order to compare the patterns of early medieval land use with those of the Romano-British period. This data represents a snapshot of the archaeological record as of April 2009, when it was extracted. In addition data from the Portable Antiquities Scheme (PAS) was downloaded from the PAS website. A considerable amount of filtering of this raw data was required, for the most part to address multiple-indexing of site records (where there were more than one HER record for a single site). This was particularly the case for the findspots.

In total the Lowland Cornwall dataset consisted of 9,031 site records, of which 8,969 were taken forward into the next stage of the project. This involved correlating the sites with HLC Types by intersecting and joining the dataset with the HLC layer in the project GIS. Once this had been done it was then possible to create the high level models. The first step was to establish that distributions apparent from the correlation exercise were statistically significant and that they were not simply representing by-chance patterns. This was done using the Chi-Squared test, a standard statistical procedure commonly applied to predictive models. Chi-Squared testing indicated that there was a statistically significant correlation between site distribution and HLC Types for all site types except hillforts. Consequently no attempt was made to create a model for hillforts, but all the other site types were modelled.

Three zone models, with high, medium and low probability zones were made based on simple techniques developed in the Netherlands. These involve taking the proportion of sites captured in any given HLC Type and comparing this figure with the proportion of the project area taken up by that HLC Type and then using a mathematical formula to express that relationship. The formula used was one known as the K_j parameter. The K_j parameter not only ranked each HLC Type in descending order of predictive

importance, but also provided an indication of where to define the cut-off points between the three probability zones. The overall performance of each model was expressed by another commonly used formula known as the Kvammes Gain measure.

Models were created for all the field systems in the dataset as well as for just those visible as cropmarks and only those with upstanding remains. All three models captured a high proportion of the field systems in their high probability zones, but the model for those with extant remains is likely to be retrodictive, merely showing where field systems have been recorded rather than where unrecorded examples might be found in the future. For this reason the model for cropmark field systems was taken as the more useful predictor. Its high probability zone was formed by the HLC Types Farmland Medieval, Farmland C20 and Farmland Prehistoric.

The same three HLCV Types formed the high probability zone of the model for rounds and enclosures, thereby broadly supporting the previously made assertion that the HLC Zone Anciently Enclosed Land represents the zone of prehistoric and Romano-British settlement. Although the high probability zone captured more than three quarters of the sites, it covered a large part of the project area and therefore achieved only a modest Kvammes Gain. The model for cropmark rounds and enclosures performed similarly, whilst the high probability zone of the model for extant sites included the Types Coastal and Upland Rough Ground in addition to the three HLC Types mentioned above.

The model for unenclosed settlements was, however, quite different. Its high probability zone consisted of a wide range of HLC Types, but the two highest-ranked forms of Rough Ground, and the Type Farmland Medieval was ranked in the medium probability zone. However, fewer than 10% of the settlements are recorded as cropmarks so this model is heavily biased towards those areas where extant remains are most likely to survive, and is essentially retrodictive. In fact cropmark settlements are most likely to be found in Farmland Medieval and Farmland C20.

Similarly the model for Bronze Age barrows appeared to be influenced by the high proportion of barrows with extant remains in the dataset. The high probability zone was made up principally of Rough Ground, Farmland Post Medieval and Farmland C20 (both of which can be seen as former rough ground). This is despite the fact that the HLC Type Farmland Medieval captures more barrows than any other. However, when only the cropmark barrows were modelled the indication was that they are most likely to be found in Farmland Post Medieval and Farmland C20. So overall it appears that Rough Ground and former Rough Ground were the favoured settings for barrows.

When the early medieval settlements were modelled the highest-ranked HLC Type in the high probability zone was Farmland Medieval. This is unsurprising, given that the location of early medieval settlements was used as evidence to define Farmland Medieval during the HLC project.

The models created for findspots are best regarded with suspicion. Although the HLC Type Farmland Prehistoric is ranked highest in each model, Farmland Medieval was consistently lowly-ranked. This is difficult to explain because this land class represents the present day farming heartland, containing most of the county's plough land, and it follows that this is where most field walking has taken place. In fact there has been no systematic programme of field walking in Cornwall as a whole and consequently the models are based on a dataset biased towards the areas of research of a small number of active finds collectors.

The models were then tested using data contained in the Cornwall and Isles of Scilly Events Record. Much of this data had not been input to the HER so provided a useful independent data sample for testing purposes. The dataset was filtered to events considered to have little potential and a variety of other reasons. Once this was done polygons were drawn around each event using field boundaries on current OS maps as the polygon boundaries. In total 694 polygons were created, covering a total area of

54.36 square kilometres, and these were then linked to the HLC layer in the project GIS by means of a spatial union.

Using a simple calculation based on sites per square kilometre it was possible to calculate how many sites in the Events dataset could be expected to be captured in each probability zone of the models. Testing was carried out using all the sites in the events dataset and then only the previously unrecorded sites, and was based on numbers of sites (point data) and area surveyed (polygons). One overarching outcome of the test process was the much higher number of sites recorded in the events record than might be expected from analysis of the distribution of known sites listed in the HER. Although this is more marked for some site types than for others, taken as a whole the implication is that there are 3.5 times more prehistoric or Romano-British sites awaiting discovery in Lowland Cornwall than are currently recorded in the HER.

The tests validated the rounds and enclosures model, with the high probability zone performing as well as or better than expected. The field systems in the events record also fit the model reasonably well whilst at the same time suggesting that the likelihood of finding field systems in the medium probability zone is understated in the original model.

The tests for the other site type models did not work as well. When the barrows model was tested the test based on all the barrows in the events record proved a good fit, but when testing was based only on the previously unrecorded barrows the model was rejected. In this case the medium probability zone captured more barrows than expected at the expense of the high probability zone. This appears to endorse the suggestion that the barrows model is heavily influenced by the distribution of barrows with extant remains and that plough-levelled barrows are as likely to be found in farmland Medieval, which makes up the bulk of the model's medium probability zone.

Conversely the unenclosed settlement model was rejected, with only half as many sites as predicted captured in the high probability zone. However, when the distribution of previously unrecorded sites was tested against the rounds and enclosures model a close fit was achieved for the high probability zone. This suggests that the model for rounds and enclosures is a better indicator of those areas where undiscovered unenclosed settlements are most likely to be located in the future.

The findspots model was rejected, with the low probability zone capturing almost three times as many sites as the high probability. This does appear to confirm that the pattern of finds distribution presented by the HER derives from a biased sample.

Part 1: Overview

1 Introduction

1.1 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 archaeological potential 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 HLC as a predictive tool for justifying planning conditions to 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 statistical 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 Historic Environment Record (HER) 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 agenda and contributes towards developing our understanding of historic landscape character.

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

1.2 Aims and objectives

1.2.1 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 both 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.

1.2.2 Objectives

1. To review currently available HER, 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 Historic Landscape Characterisation (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.

1.3 Report layout

The project comprised three distinct stages and generated an enormous amount of data. In order to present the results of the project in an accessible format, the final report is published as five separate volumes.

1.3.1 Volume 1

During stage one data for selected site types was extracted from the Cornwall HER and correlated with the existing HLC Types in order to identify recurring distribution patterns and to create high level predictive models. Volume 1 (this volume) presents the outcome of this work, describing the methodology used to create the models, the results of the modelling and a discussion and set of conclusions drawn from this research. Volume 1 also outlines the background to, and scope of, the whole project.

1.3.2 Volume 2

Also during stage one an assessment was made of the extent to which additional 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 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 presents the results of this research.

1.3.3 Volume 3

Stage two involved refining or deepening HLC in four selected study areas. The HLC refinement comprised 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 HLC refinement are presented in Volume 3.

1.3.4 Volume 4

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

1.3.5 Volume 5

Volume 5 presents a summary of the information contained in Volumes 1 – 4.

2 Background

2.1 Cornwall's physical geography

2.1.1 Overview

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 deposits of alluvium and 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 of them 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 (these figures are provided by the Cornwall Council's Spatial Planning Department).

After farming, the most important industry 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 manufacturing industry, and is focused on the Hensbarrow area to the north of St Austell. This industry has had a significantly adverse impact on the archaeological landscape that preceded it.

2.1.2 Geology

Cornwall is dominated by a spine of granite bosses. The four main ones are 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 east-west, and lead, zinc and iron in lodes running north-south. At a later stage some granites were altered, the most widespread instance 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 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.

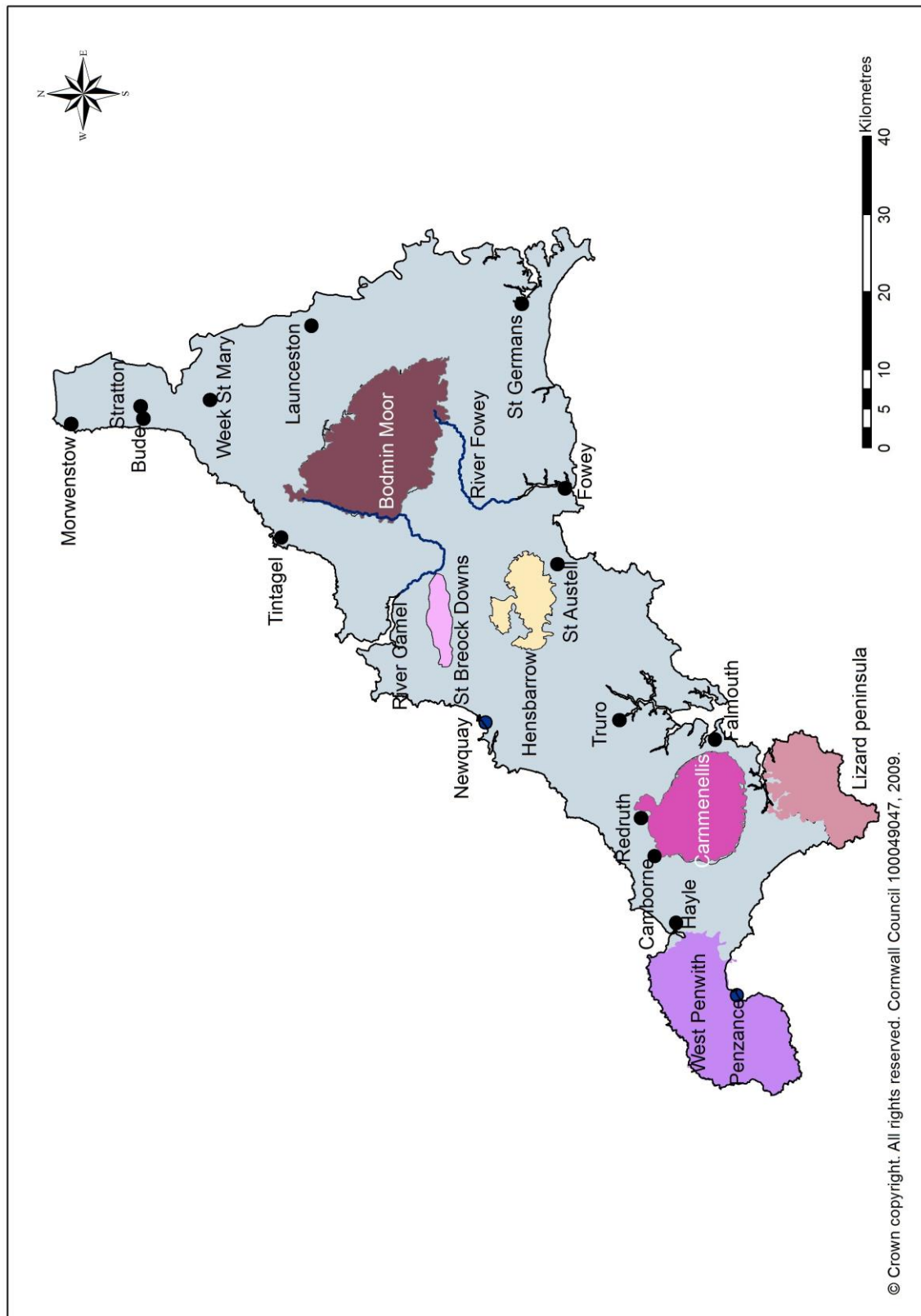


Fig 1 Map of Cornwall showing some of the places and areas mentioned in the text

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, shale, slates, siltstones and sandstones.

During Pleistocene times 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 submerged coastline (e.g. the rivers Fal, Fowey and Helford).

2.1.3 Soils

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

Cornwall is covered predominantly by brown earths associated with stagnogley soils, brown podzolic soils and rankers (Soil Survey of England and Wales, 1974). The Devonian Killas, covering most of the county, yield a clayey loam with 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.

2.2 Current models for prehistoric landscape development

Extensive archaeological field work has mapped large tracts of Cornwall's surviving upland historic landscapes, in particular on Bodmin Moor and a substantial part of West Penwith. 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 is set out as a narrative in a paper by Peter Herring (Herring 2008). Herring identifies, from different and superimposed settlement and field patterns, a series of key reorganisations of the Cornish farming system undertaken on a wide scale in response to changing pressures on land and resources, both upland and lowland.

The earliest definable patterns, from the middle Bronze Age, can be traced on Bodmin Moor. Towards the fringes of the Moor unenclosed round house 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 round houses 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 around the mid second millennium involved the laying out of extensive coaxial field systems with round houses 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. The coaxial fields better organised the enclosed farmland (and in places extended its limits) and formalised access to the grazing land beyond.

Reorganisation in the late Bronze Age/early 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 (rounds) 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. Rounds were abandoned and replaced by open hamlets, many of which have Cornish names prefixed with *Tre*. Many of these early medieval settlements are situated close to abandoned rounds and it is suggested that some may be overlying the site of former rounds (Rose and Preston-Jones 1995, Johnson 1998). The early medieval settlements were accompanied by 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 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 pattern 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 same way that we do for the uplands. We have keyhole glimpses of areas of potential, but are lacking a demonstration of the hidden landscape on a scale that gives both patterning across the landscape and an adequately detailed picture of the resource.

3 Project scope

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 HER provided core data for the project and three other principal sources of currently available data were used.

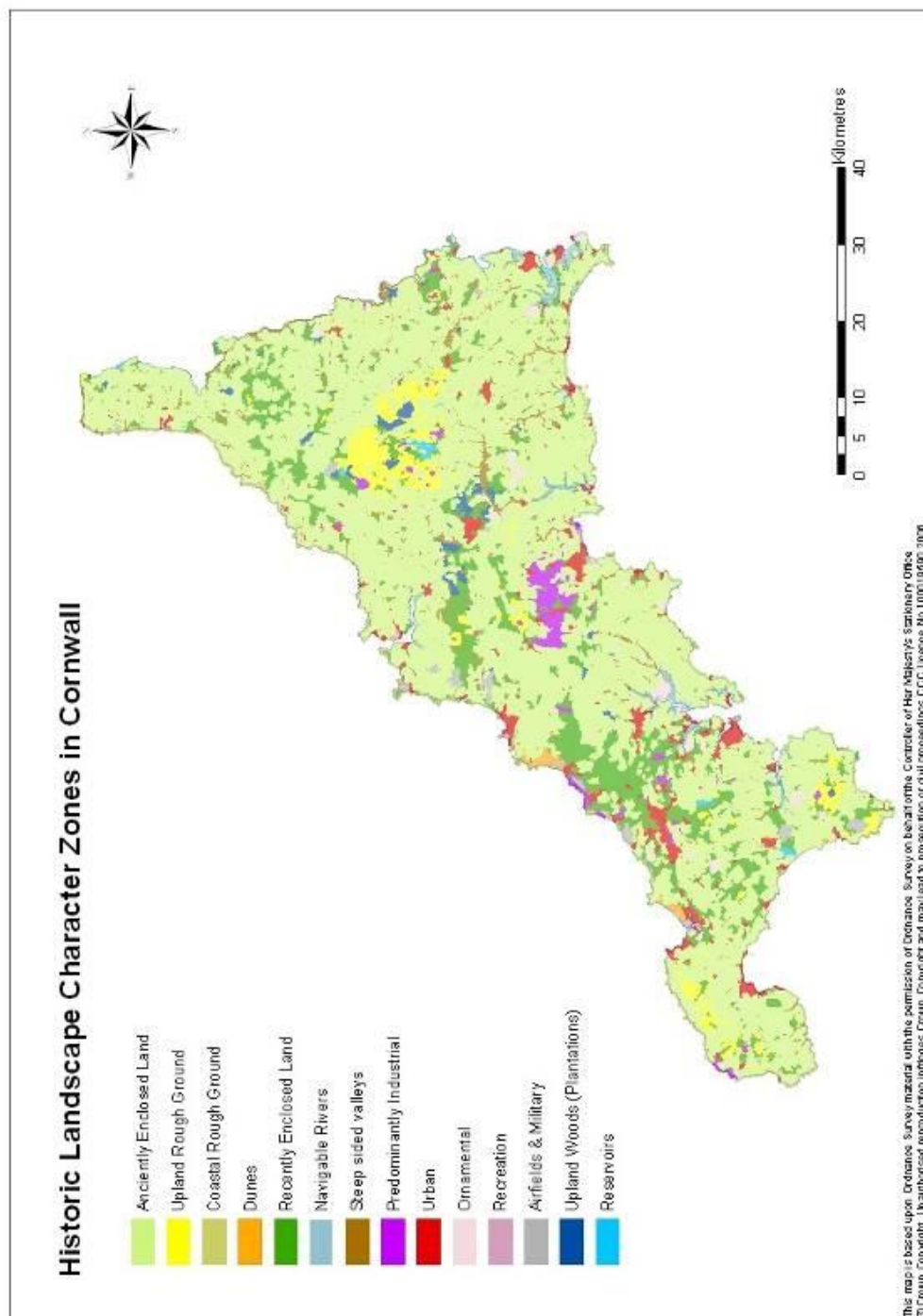


Fig 2 Historic Landscape Character Zones in Cornwall.

3.1 Data sources

3.1.1 Historic Landscape Characterisation (HLC)

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 EH. 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 Types, 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.

Cornwall was the first county to carry out HLC (Herring 1998) and the method used was largely *prescriptive* (fitting areas of land, on the basis of morphology, into pre-defined historic landscape types). More recent characterisations are based on a *descriptive* approach (determining historic landscape character by ascribing attributes to polygons without initially assigning interpretations to historic landscape character; interpretation is then introduced at a later stage in the process).

3.1.2 Cornwall's National Mapping Programme (NMP)

The National Mapping Programme is funded by EH 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 HER were either created or enhanced by data from the project and 75% of the sites identified were new to the HER.

Mapping methodology evolved over the course of the project; the most significant development was the change from manual to digital mapping in 1998. Because not all the mapping was produced digitally, NMP data is displayed as two separate layers in the HE GIS: the digital mapping as a Vector layer; the non-digital mapping as a Raster layer. A further technological development in 2000 enabled HER data to be attached to the Vector images. Fig 3 shows the areas of the county where NMP mapping is displayed as a Raster layer, as a Vector layer, and as a Vector layer with data attached.

3.1.3 Events Record data

The Cornwall and Isles of Scilly computerised events record has been compiled over the last decade or so. It records all archaeological interventions for which a report has been produced and deposited with HE. These interventions include not only those carried out by HE, 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 are contained in the events database. Reports produced by HE are in PDF format and can be accessed by a link in the events record database.

3.1.4 Other sources of data

NMR data

During Cornwall's NMP project it was established that no site records additional to those already contained in the HER are held in the NMR, other than a small number relating to the built environment. For this reason NMR 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 (Lowland Cornwall Volume 3).

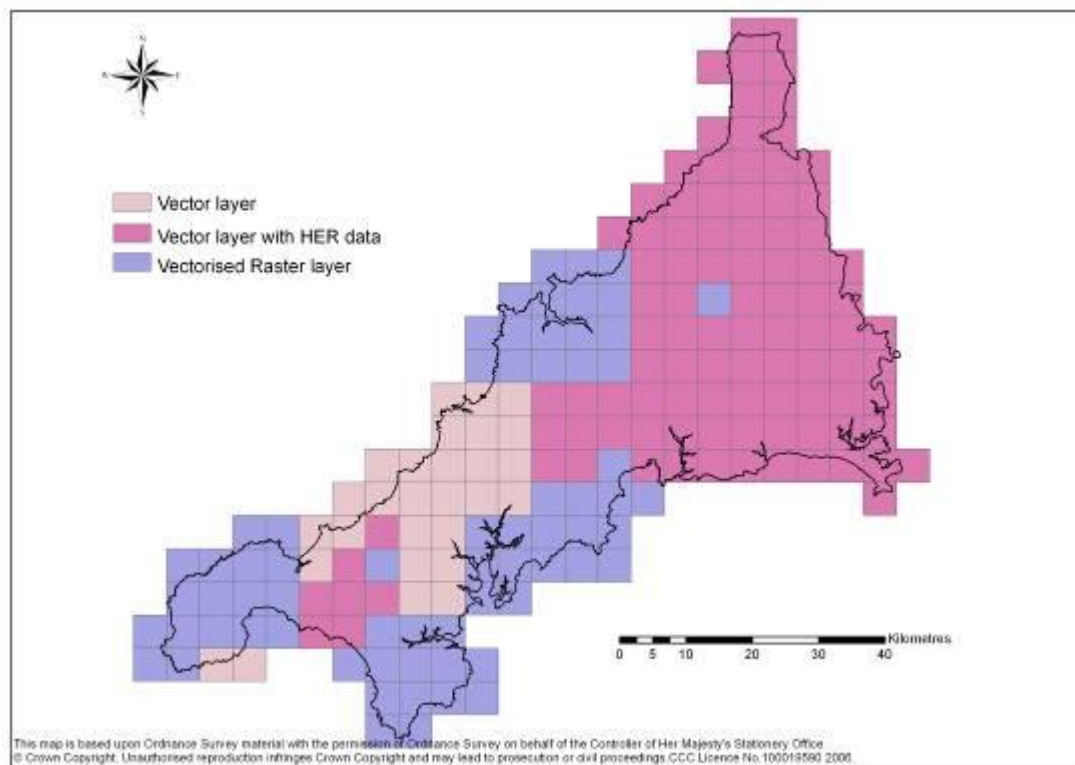


Fig 3 NMP mapping in Cornwall, 1994 – 2006

Portable Antiquities Scheme (PAS)

Data from the PAS in Cornwall can be downloaded from the PAS website (www.finds.org.uk) free of charge. This information was displayed as point data in the GIS to augment records for find spots contained in Cornwall's HER. PAS data was consulted during the course of the project but its usefulness was limited (section 8.6.7).

Palaeoenvironmental data

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

3.2 Using the data

3.2.1 Using HLC data

A key factor in the model for the prehistoric landscape outlined in section 2.2 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. For example, the Lynher Valley Project (in which almost 90% of the rounds in the project area were located in AEL) bears this out (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 interaction with Rough Ground and REL, by using GIS to examine correlations between HER data, NMP data, Events Record data, and HLC.

One of the principal benefits of HLC in Cornwall lies in its application as a predictive model, with each HLC Type apparently having its own distinctive range of typical archaeological components and features (Herring 1998). This application could be more effective if understanding of the HLC Types forming AEL and REL were to be refined. In the presentation of Cornwall's HLC method (Herring 1998, 26-28) it is noted that the mapping of the HLC Type *Farmland Prehistoric* is currently unsatisfactory and it is suggested that the HLC Type *Farmland Medieval* could be subdivided into a range of sub-types. Subdivision along these lines would bring the Cornwall HLC closer in terms of granularity of characterisation and utility of output to the HLC for other counties.

Since the HLC for Cornwall was implemented in 1994, a number of HLC projects have been carried out in discrete study areas within the county, such as the Lynher Valley Project mentioned above, and these have deliberately adopted a more attribute-led methodology (e.g. Tapper and Herring 2005). An important outcome of these projects is the understanding that attribute-led refinement of REL can more closely identify the extent of HLC Types that represent rationalisation of medieval enclosure rather than the post medieval enclosure of rough ground. Considerable tracts of REL are actually reorganised AEL systems and not newly enclosed commons, and understanding these may demonstrate how different types of REL have affected the visibility and survival of elements of the prehistoric and Romano-British landscape.

For this reason a key element of the Lowland Cornwall project is the refinement or deepening of HLC in four discrete study areas selected from the overall Lowland Cornwall project area (Lowland Cornwall Volume 3). The spatial correlation of HER, NMP and Events Record data with the refined HLC types and sub-types was explored using GIS in order to make the predictive application of HLC more precise through the identification of trends and patterns. It is hoped that the development of methods to pursue this process achieved by this project will be of value in other parts of England where large areas are dominated by modern field patterns set within landscapes whose settlements, roads and archaeological record indicate much deeper histories.

3.2.2 Using NMP data

In lowland Cornwall the most visible element of the prehistoric landscape is the distribution of approximately 380 Iron Age/Romano-British enclosed settlements, known in Cornwall as rounds, which survive as upstanding monuments. The substantial banks and ditches of plough-levelled rounds readily form cropmarks and a significant number of these have been identified from aerial photographs. During Cornwall's NMP more than 1,000 new rounds and 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, round houses (usually sited within a few metres of rounds) 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. Field systems, for instance, invariably appear to be fragmentary and the fields generally appear to be much larger than the brick-shaped fields found in, for example, West Penwith, suggesting either that not all the boundaries are visible, or that different patterns of field enclosure were developed in lowland Cornwall.

On a broad level NMP mapping of cropmark rounds 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.

A key element of the project was an assessment of the degree to which 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 (Lowland Cornwall Volume 2).

3.2.3 Using Events Record data

A more detailed picture of individual sites and features forming the buried prehistoric landscape is provided by the results of excavations, geophysical surveys and watching briefs carried out by HE and other organisations or individuals over the last 50 years or so. More than 3,000 interventions are listed in the HE events record. Of particular relevance to this project are records for

- 366 watching briefs
- 259 geophysical surveys
- 159 excavations
- 66 minor excavations
- 64 major excavations
- 20 site surveys
- 20 field walking surveys

This quantification of events is approximate as it contains a number of duplications (for example there are individual records for interim reports covering several seasons of work on one excavation). Nonetheless it plainly constitutes a large amount of archaeological research. The greater proportion of this work has been carried out over the last 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. Although many of these are relatively small scale or site-specific, some are more extensive and roughly 100 are associated with linear developments including a number of major road improvements. The surveys have been carried out throughout all areas of the county, on a variety of geologies and using a range of techniques and have frequently been followed up by evaluation and, sometimes, excavation. Important results of the surveys include the identification of rounds not visible on aerial photography, associated field boundaries, contemporary external round houses, and evidence of earlier activity in the surrounding landscape. Evidence for the pre-Iron Age landscape has been recorded in the form of Bronze Age round houses at a number of lowland locations.

Part 2: High level overview

4 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 consistently above the level of the surrounding country. However, height above sea level in itself is not a definitive guide to identification of upland areas; there is a southerly tilt to the land mass caused by uplift during the Mid-Tertiary (Stanier 1990, 20). The effects of this can be seen clearly in Fig 4, showing land above the 150m mark.

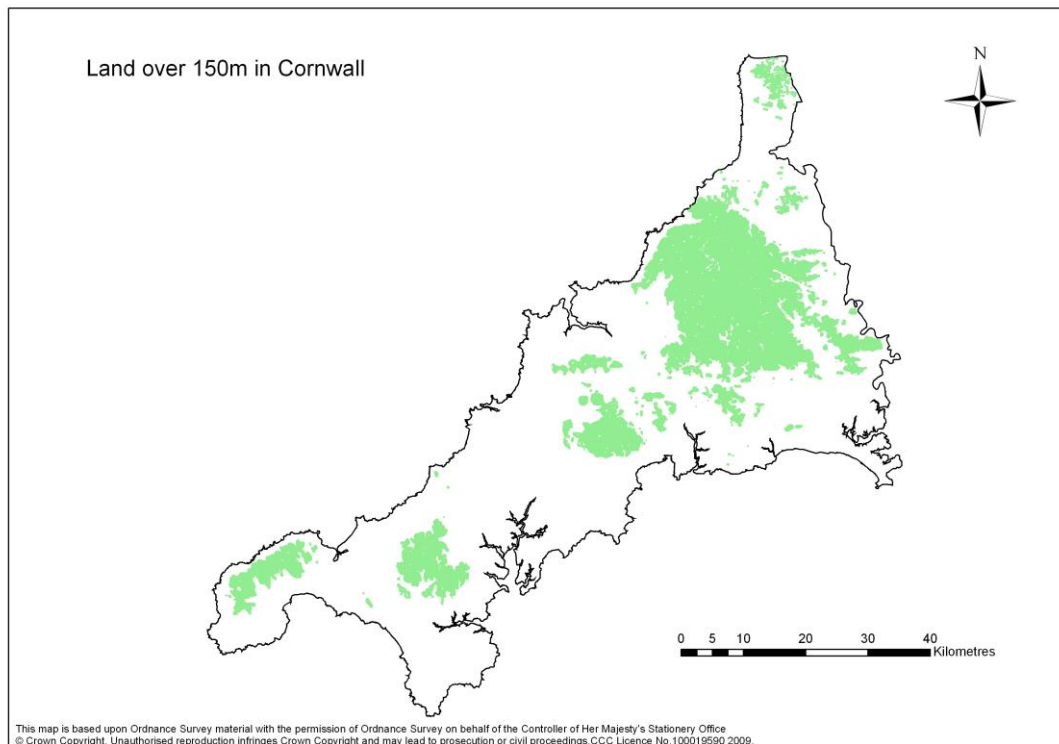


Fig 4. Land in Cornwall over 150m OD

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 both the area north of Bodmin Moor and that to the east of Bude, whilst containing much high ground, are characterised by extensive areas of farmland more consistent with the concept of a 'lowland' zone.

The upland zone of Britain has been described as containing human settlement which is essentially discontinuous, with cultivated areas separated by expanses of uncultivated hill lands. 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).

So in the context of Cornwall the greater part of the lowland zone contains '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 is clear that habitat data forms 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 consist of the 1995 ERCCIS Habitat Land cover data and Agricultural Land Classification. These data are shown below in Figs 5 and 6.

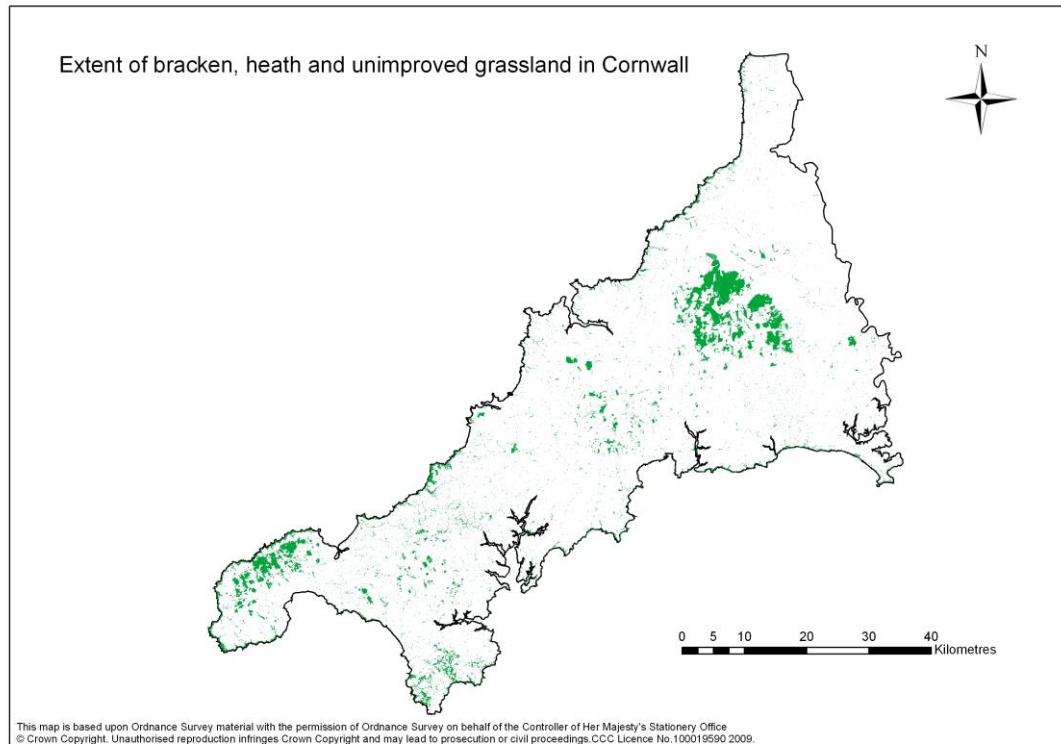


Fig 5. 1995 ERCCIS Habitat Land Cover data showing the extent of bracken, heath and unimproved grassland in Cornwall.

In both maps the Bodmin Moor and West Penwith granites include extensive areas of wastes and unimproved land as well as poorly-graded agricultural land. To a lesser extent the Hensbarrow and Carnmenellis granites give rise to wastes and unimproved land and whilst Hensbarrow is characterised by poor agricultural land, this is not the case with Carnmenellis. Both maps differ from the elevation map (Fig 4) in that Goonhilly Downs and Predannack Downs on the Lizard can be characterised as upland areas in terms of their vegetation and agricultural land class even though both areas are relatively low-lying.

A further consideration is Cornwall's HLC. On a basic level this distinguishes between 'enclosed land', equating to cultivated or improved land, and 'open land', equating to wastes, heathland and other unimproved land. Fig 7 shows the extent of open land represented by the HLC zones Upland Rough Ground, Upland Woods and Predominantly Industrial. The HLC zone Predominantly Industrial is included because it is confined for the most part to the Hensbarrow china clay area which was formerly made up predominantly of heath and unimproved land.

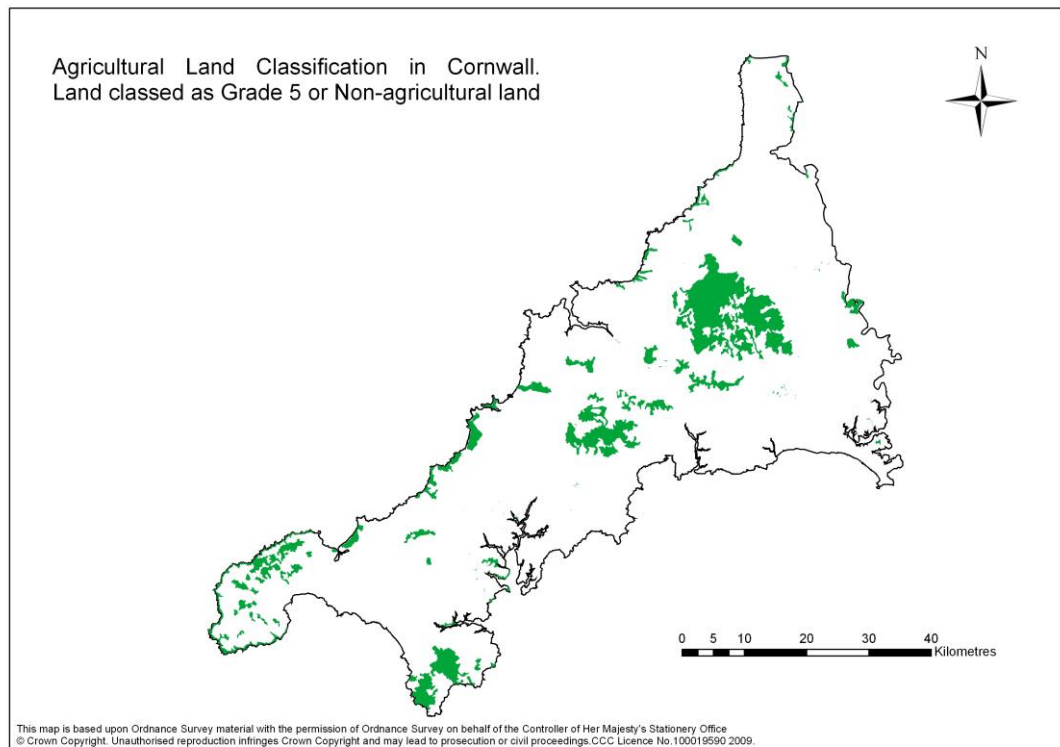


Fig 6. Agricultural Land Classification showing land classed as Grade 5 and land classed as Non-agricultural.

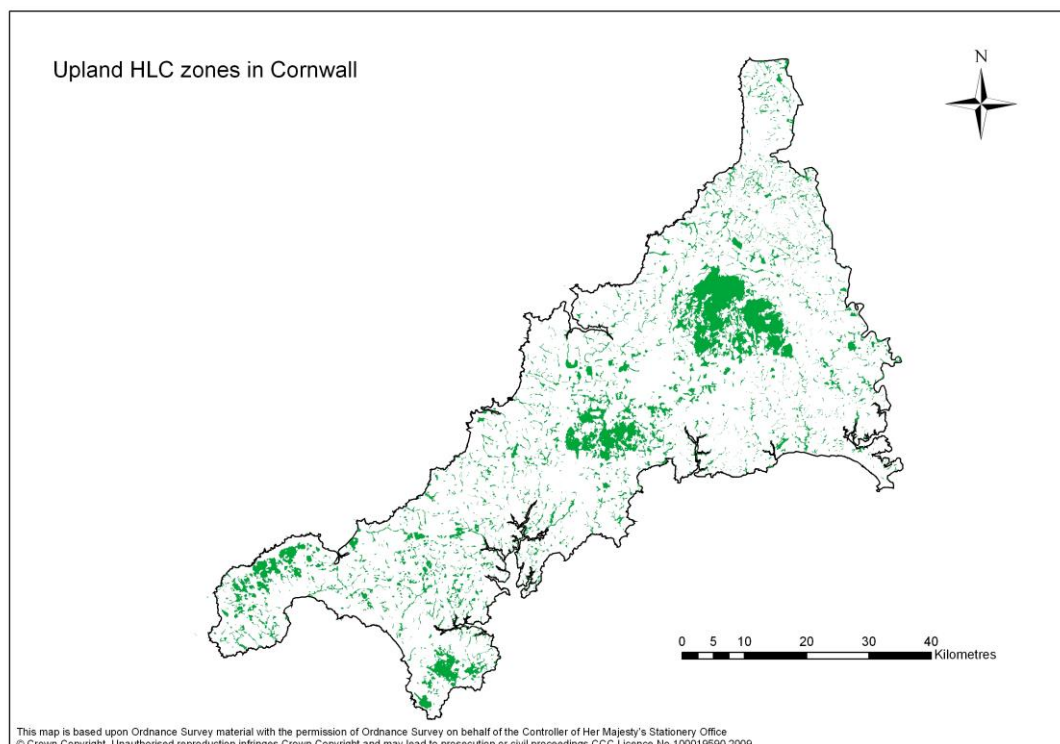


Fig 7. The extent of Upland Rough Ground, Upland Woods and Predominantly Industrial HLC zones.

By juxtaposing the habitat, Agricultural Land Class and HLC layers shown in Figs 5–7, an overall impression of the extent of the area with upland character can be gained. This is shown in Fig 8.

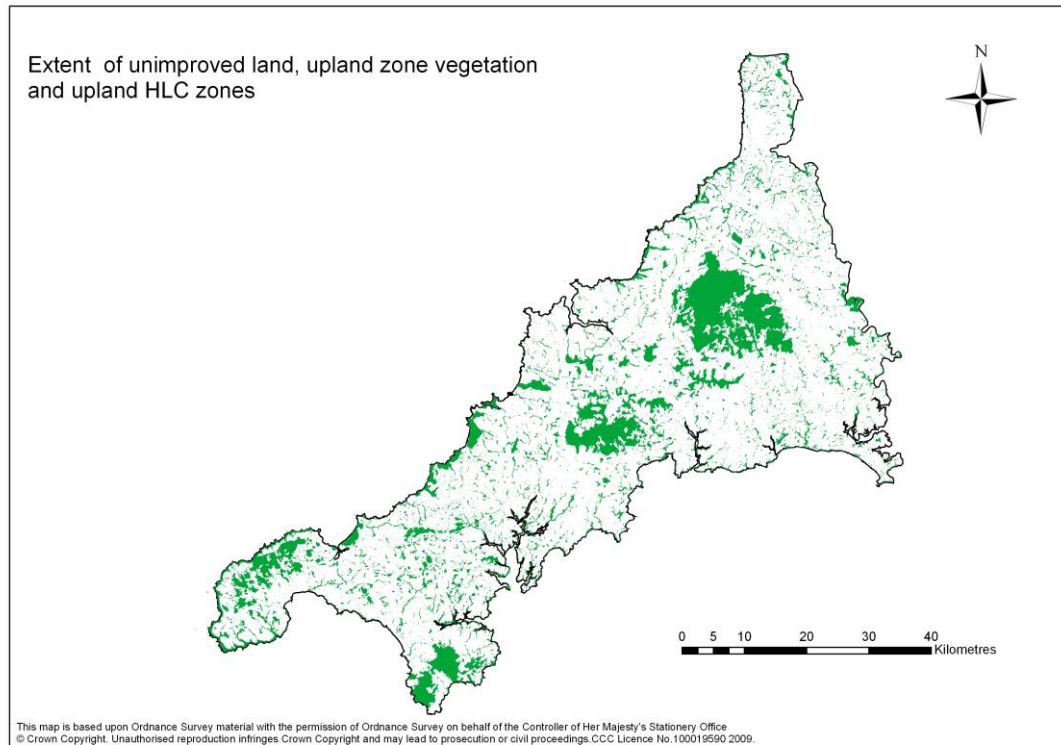


Fig 8. Overall extent of the area with upland character

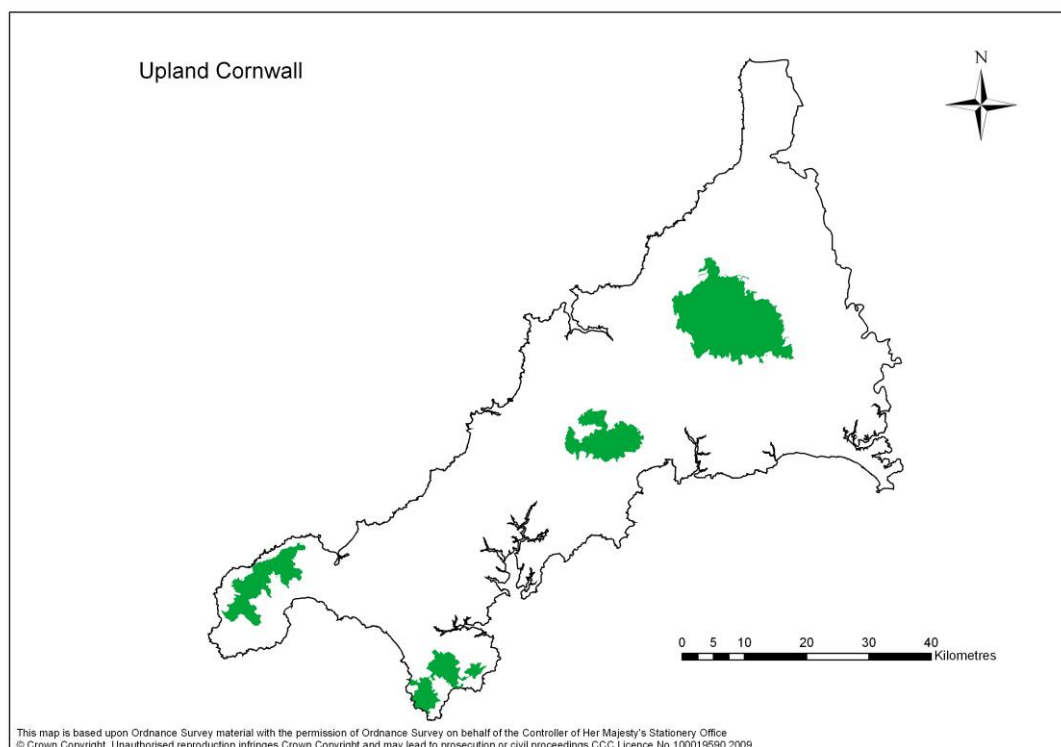


Fig 9. Upland Cornwall.

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 (Fig 9). These are Bodmin Moor, Hensbarrow, the

Lizard downs and parts of West Penwith. This rationalisation of the topography is somewhat rudimentary and areas such as Carnmenellis are not included in the upland zone and nor are the tracts of coastal rough ground found along parts of the north coast (Fig 8). It is, however, consistent the definition of uplands above and, by the same token, the white area in Fig 9 is consistent with the definition of lowlands.

For this project, then, lowland Cornwall is defined as the white area in Fig 9. 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 3189.8 sq kms and the full range of HLC Types are found within it.

5 The project sites dataset

5.1 Methodology: creating the project sites dataset

5.1.1 Assimilating the raw data

Data relating to selected site types was extracted from the Cornwall HER using Access Make Table Queries. 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 HER after that date was not considered as part of the Lowland Cornwall project. The selected site types were:

- Hillfort
- Hut circle
- Barrow
- Field system (where 'Display date' = Prehistoric)
- Field boundary (where 'Display date' = Prehistoric)
- Round
- Cliff castle
- Cemetery (where 'Display date' = Prehistoric)
- Enclosure (where 'Display date' = Prehistoric)
- Findspot (where 'Display date' = Prehistoric)
- Early medieval sites

Find spots were extracted by searching the HER by 'Form' where 'Form' = Artefact.

Early medieval sites were extracted by searching on 'Period'.

The 'Display date' Prehistoric comprises a date range from Palaeolithic – the end of the Roman period.

Fields included in the Access tables were:

- PRN
- 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)
- 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)

The resulting query tables, containing raw data, were exported as DBF files which were then brought into Arcview as point data. Site records located outside the Lowland Cornwall project area were then removed from the dataset by using the clip facility in the Arc Toolbox.

5.1.2 Data verification

Duplicate site records

There were a number of issues with the raw data. The most significant was the multiple-indexing of sites resulting in duplicate records appearing in the Access tables. The circumstances in which this occurred are best illustrated by considering a hypothetical example, in this case a round interpreted as either Iron Age (IA) or Romano-British (RB) in date. This site will have been entered in the HER as a single record (e.g. PRN 50000) with two alternative dates 'IA' and 'RB'. When running the Access Query Table, however, this site will be listed as two separate sites;

1. Round, PRN50000, IA
2. Round, PRN50000, RB

The majority of HER records for rounds were multiple-indexed in this way.

Another frequent example of multiple-indexing is where a round has alternatively been interpreted as an enclosure. Again the Access table would contain two entries for the same site (Round, PRN50000; Enclosure, PRN50000). If the same site were interpreted as either IA or RB then the Access table would contain four separate entries (Round, PRN50000, IA; Round, PRN50000, RB; Enclosure, PRN50000, IA; Enclosure, PRN50000, RB).

A third regularly occurring (although less frequent) cause of multiple-indexing is where a site is partially visible as an earthwork (an 'extant' site) and partially as a cropmark and consequently two entries have been made in the 'Form' field in the HER. In this case two entries would appear in the Access table: Round, PRN50000, Cropmark; Round, PRN50000, Extant. If this site had been dated as IA or RB then four records would be listed in the Access table, and if it had been interpreted as round or enclosure then six separate records would be listed.

Although multiple-indexing primarily affected records for rounds and enclosures, records for field boundaries, field systems and hut circles were also frequently multiple-indexed by date and/or form, and Bronze Age (BA) barrows were sometimes multiple-indexed as Prehistoric enclosures (in cases where they survive as cropmark ring ditches).

The initial focus of verifying the data was deleting all duplicate numbers: essentially to end up with a table containing unique PRNs each representing a single site. A number of automatic data verification techniques using Arcview and Access were explored but none proved satisfactory. As a result, verification was carried out manually using the following parameters.

Period verification

- Where period was recorded as both IA and RB, the IA value was retained and the RB value deleted.
- Where period was recorded as Prehistoric (PX) and RB, the PX value was retained and the RB value deleted.
- Where period was multiple-indexed as both BA and IA, only one record was retained and the period was changed to PX (except in the case of enclosures where IA was retained).

- Where period was multiple-indexed as IA, PX and RB, the PX value was retained and the IA and RB values deleted (except for rounds and hillforts where IA was retained).
- Where a site was multiple-indexed as an IA round, an RB round and a PX enclosure, the IA round value was retained and the RB round and the PX enclosure values were deleted.
- Sites multiple-indexed as 'barrow' or 'round house/hut circle' will appear twice in the project data set – firstly in the distribution of barrows; secondly in the distribution of round houses.

Form verification

- Where form was multiple-indexed as *Site Of* and *Extant*, the *Extant* value was retained and the *Site of* value deleted.
- Where form was multiple-indexed as *Site Of* and *Cropmark*, the *Cropmark* value was retained and the *Site of* value deleted.
- Where form was multiple-indexed as *Documentary* and *Extant*, the *Extant* value was retained and the *Documentary* value deleted.
- Where form was multiple-indexed as *Documentary* and *Cropmark*, the *Cropmark* value was retained and the *Documentary* value deleted.
- Where form was multiple-indexed as *Extant* and *Cropmark*, the *Cropmark* value was retained and the *Extant* value deleted.

5.1.3 Qualitative verification

A number of site records can be 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 (e.g. Quinnell 2004, 211). Therefore all records in this category were deleted. On the other hand Cornish field-name evidence (names with Cornish elements, such as 'Ker', 'Caer' etc) was accepted as potential evidence and sites in this category were retained.

Hut circles

The listings contain a significant number of hut circles 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 deleted 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, BA, or Mound, Unknown date (UX). In some cases (those located in Cornwall's mining districts) they were multiple-indexed as Mound, UX, Barrow, BA, and Spoil Heap, PM (Post medieval). Given the level of uncertainty over interpretation of these features none were retained in the dataset.

5.1.4 Find spots

The find spot dataset offered significant challenges in terms of analysis and an initial decision was taken that for the development of the high level model a generalised analysis would suffice to provide an overview of prehistoric finds distribution.

The find spot data contains extensive multiple-indexing, resulting from three principal causes.

- Alternative period interpretations (IA/RB, BA/IA, Neolithic (NE)/BA, Mesolithic (ME)/NE, ME/NE/BA, etc.).
- More than one type of Material found at the same site (e.g. flint, pottery, shell and wood)
- More than one type of Object falling into the same category of Material (e.g. Material = flint, Object = fabricator, flake, blade, scraper)

For many records all three factors come in to play and it is not unusual for any one find spot to appear in the Access table as 10 or more separate records.

Multiple-indexing by Period

To arrive at a dataset containing a single record for each find spot, the issue of duplicate records caused by multiple-indexing by Period was resolved by retaining the record with the earliest period value and deleting the others from the table. This means that in cases where there was uncertainty over dating, for example where a flint assemblage has been recorded as possibly ME, NE or possibly BA, in the project database it will be entered as ME only. Similarly if an HER record includes ME, NE and BA material at the same site only the ME material will register in the project database. Whilst this was not considered ideal, it was felt the need for each individual site record to be represented by a single point took priority over inclusiveness: multiple points representing a single site would have the effect of distorting the site counts for each HLC Type, rendering the resulting models invalid. Finally the finds dataset was subdivided into IA and RB finds and Prehistoric finds (all periods from Palaeolithic to Bronze Age).

At a later stage in the data verification process it was concluded that the finds dataset created in the way described above, whilst accurately representing one point per find spot, did not fully represent the full range of information available. In particular, limiting the period value to one entry per record might bias the dataset in favour of the earlier periods (i.e. ME in favour of NE; NE in favour of BA).

Therefore the dataset was analysed again and additional tables were created for each period: Palaeolithic (PA) finds, ME finds, NE finds and BA finds. Within each of the tables all duplicate records based on multiple-indexing with monument site types were removed and all duplicate records based on multiple-indexing of Material were removed (see below).

The outcome of verification of the finds data meant that the overall distribution of finds (one record per site) could be analysed, the finds from each period could be analysed, or the finds could be analysed on the basis of material.

Multiple-indexing by Material

Multiple-indexing by multiple Object and Material types is a complex issue. In resolving it the following parameters were adhered to as far as possible.

No account was taken of Object and decisions whether to retain or delete records were taken solely with regard to the types of Material. A 'hierarchy' was developed whereby some Material types took precedence over others.

As an example, in situations where a single find spot is represented by a record for bone material and a record for shell material, the record for bone takes precedence over the record for shell (the bone record was retained and the shell record deleted). Other cases of multiple-indexing are listed below

- Records for horn took precedence over records for bone.
- Flint took precedence over horn
- Chert took precedence over flint
- Stone took precedence over chert
- Granite, quartz and greenstone took precedence over stone
- Wood took precedence over granite, quartz and greenstone
- Pottery took precedence over wood
- Metal took precedence over pottery
- Copper alloy took precedence over metal
- Iron took precedence over copper alloy
- Tin took precedence over iron
- Silver took precedence over iron
- Gold took precedence over silver

Thus a multiple-indexed record for finds of flint and bone would be entered into the project database as a record for flint. A double indexed record for shell, flint and pottery would be entered as a record for pottery. A record double indexed for pottery and copper alloy would be entered as a record for copper alloy.

Multiple-indexing with monuments

A further issue regarding records for finds is that because the data was extracted by searching for records where Form = Artefact, some of the resulting records were for finds made during investigations of monuments. The list of site types included those such as 'cist', 'barrow', 'enclosure' and 'cemetery'. These records were removed from the data set in order that the distribution of finds is independent of the distribution of the various monument types considered in the models. The site types retained in the finds data set is listed below.

- Findspot
- Artefact scatter
- Lithic scatter
- Lithic working site
- Metal processing site
- Occupation site
- Settlement
- Coin hoard
- Socketed stone
- Cup marked stone

5.1.5 Early medieval monuments

The complete body of early medieval (EM) sites were extracted from the HER in order to compare the patterns of early medieval land use with that of the Romano-British period in order to shed light on the RB/EM transition.

The raw data contained a considerable number of records whose Form is Artefact (most of which are find spots) and, of these, many comprised a range of different objects (for instance the objects from a find spot at Mawgan Porth included pottery, silver, shell, bone, iron and a granite quern). These records are multiple-indexed, with a separate

listing for each different object. The Mawgan Porth find spot (PRN 22101.6) appears in the Access table as 18 separate records. The artefact records were rationalised so as to read one record per site in the same way used to resolve similar issues arising from the find spot data set described above.

Further refinement of the dataset involved the removal of a small number of records considered to be surplus to the purpose of the project. These consisted for the most part of church fittings, such as altar, font and gravestone. Single records for a bridge and a battlefield were also removed.

5.1.6 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 the analysis is based. There are weaknesses in all the datasets used in this project which need to be borne in mind when considering the results of the analysis.

The HER was the primary source of information regarding archaeological sites in lowland Cornwall and, in common with the HERs 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. On a broader level an open settlement consisting of five round houses (for example) might have been input as a single record for 'settlement', but a similar site elsewhere might have been input as five separate records for 'round house'. This type of inconsistency will have obvious repercussions for any analysis of the data based on numbers of sites.

Another weakness of some HER data is that it is based on interpretation rather than certainty. An example, mentioned in this report (section 5.1.3), 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 HER data is a potentially significant issue: rounds 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. Or, alternatively, that the early medieval settlement was named with 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 presented in this volume. 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 required for this make such a task a totally unrealistic proposition. However, coincidental follow-up work has been carried out at a number of cropmark sites in Cornwall in recent years and at some the interpretations have been verified, but at others no evidence was found and an appraisal of this work 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 (Lowland Cornwall Volume 4) but in building the high level models presented in this volume, no site verification other than the rationalising of multiple-index issues (section 5) was carried out.

There are also inherent weaknesses in Cornwall's HLC data. 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 HE GIS). More detailed examination of the HLC at specific locations as part of HE desk based assessments and other projects over the last 16 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.

The assessment of the events record data also relied to a degree on interpretation for those sites where no or only limited excavation had taken place. This was especially true of the results of geophysical surveys in which anomalies had been noted but no interpretations offered by the surveyors. During the Lowland Cornwall assessment these were all treated as archaeological features whereas in some cases the anomalies may have been caused by natural agencies.

Whilst it is important to highlight these weaknesses in the data the fact remains that the datasets used 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.

5.2 The dataset

Once the extracted data had been filtered as described in section 5.1 above, the project sites dataset contained 9,031 records for individual sites and consisted of the following components.

Site type	Number of sites	% of total sites
Barrow	2120	23.47%
Early medieval site	2116	23.43%
Findspot	1641	18.17%
Round	1332	14.75%
Enclosure	625	6.92%
Field system/field boundary	529	5.86%
Hut circle/round house	288	3.19%
PAS find spot	231	2.56%
Hillfort	87	0.96%
Cliff castle	43	0.48%
Cemetery	19	0.21%
Total	9031	

Table 1. Summary of the HER dataset

At this stage it was decided not to correlate cliff castles with HLC Types as the overwhelming majority (81%) are located in coastal rough ground. In this case there is little need for a predictive model for the location of cliff castles. It was also decided to drop the site type cemetery from the dataset because 19 records are too few to form a statistically reliable sample.

All the other site types were taken forward into the next stage of the project, which involved correlating the distribution of the sites with HLC Types.

5.3 Correlating site types with HLC

The shape files containing the various HER data were intersected with the HLC layer using the 'spatial join' and 'summary' tools in the Arcview ArcCatalog Toolbox.

Using the command 'Join data from another layer based on spatial location', the attributes of each HLC polygon were joined to each HER point falling within it.

Reports on the HLC layer and HER site type layers were then generated by exporting the attribute tables of the HER shape files into Excel tables. These presented the numbers of site records found in each HLC Type.

The results of this process are summarised in the tables below.

HLC Type	% of total HLC	No of monuments	No. of finds
Ancient Woodland	2.2	16	20
Coastal Rough Ground	1.5	275	172
Communications	0.4	16	5
Dunes	0.3	67	42
Farmland C20	10.7	752	200
Farmland Medieval	52.2	3471	529
Farmland Post Medieval	15.9	1061	292
Farmland Prehistoric	2.75	487	306
Industrial: Disused	0.4	9	9
Industrial: Working	0.2	0	2
Military	0.6	40	6
Ornamental	1.4	95	17
Plantation and Scrub	3.6	117	21
Recreational	0.6	51	12
Rough Ground/Industrial	0.1	22	1
Settlement C20	3.1	347	108
Settlement older core (pre-1907)	0.5	57	23
Upland Rough Ground	2.8	196	86
Water: Natural	0.6	16	14
Water: Reservoirs	0.1	2	7
Total		7097	1872

Table 2. List of HLC Types showing the number 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 that the HLC Types for farmland capture the vast majority of the monuments (81% in fact) and also the majority of find spots (71%). Within this farmed area, 69% of monuments and 63% of find spots are located within the HLC Zone AEL (Farmland medieval and Farmland prehistoric). Interestingly, whilst only 14% of the AEL monuments are in Farmland prehistoric (the other 86% are located within Farmland medieval), 58% of prehistoric find spots are within Farmland prehistoric and only 42% in Farmland medieval. Of course these figures are somewhat biased because the monument dataset includes early medieval sites whereas the find spot dataset comprises only prehistoric and Romano-British finds. If the early medieval monuments are disregarded, this leaves 4,981 prehistoric/Romano-British monuments, 2,557

(51%) of which are located within AEL. The percentage of prehistoric AEL monuments within Farmland prehistoric remains at 14% so that there are two very obvious conclusions to be drawn from this basic list of figures: firstly that almost three quarters of prehistoric monuments in lowland Cornwall are captured in the HLC Zone AEL, and that there is a very high likelihood of finding prehistoric artefacts in the HLC Type Farmland prehistoric.

An apparent anomaly in the correlation is the location of 11 prehistoric monuments in the HLC Type Water: Natural. Eight of these sites are Bronze Age barrows, all of which are at cliff top locations. Two are sourced from documentary references, at Pedngwinion, Gunwalloe and at Whitesand Bay, Sennen. In both cases either the barrows have fallen into the sea as a result of coastal erosion, or the quoted grid references are slightly incorrect. Four barrows are listed as being 'site of': two of these are at Harlyn Bay, Padstow, and both have fallen into the sea. The other two are at nearby Cataclews Point and again have been lost through coastal erosion. A further two barrows, also at Cataclews Point, are listed in the HER as extant and in this case the landward edge of the Water: Natural HLC polygon has been inaccurately drawn and these two barrows are, in reality, within the HLC Type Coastal Rough Ground. The HLC polygon has also been inaccurately defined at Henn Point, Saltash, where an enclosure and round house are actually located in Coastal Rough Ground at the mouth of the river Tamar. Finally there is a documentary reference to a round at Gare, St Michael Penkevil, which has most likely been mapped with an inaccurate grid reference, and is in reality located in Ancient Woodland (Penkevil Wood) lining the side of a river Fal creek.

A further five early medieval sites are recorded from Water: Natural. One of these is the early harbour at Tintagel; the HLC polygon for Water: Natural mistakenly includes the Lann and settlement of Lamorran, St Michael in Penkevil; the other two sites have been lost to coastal erosion. Similarly 13 records for find spots (eight pre-Iron Age and five Iron Age/Romano-British) are located in cliff face sites where the distinction between sea high water and the edge of the land has been inaccurately defined.

5.3.1 Rounds and enclosures

Site type: Rounds and enclosures			
HLC Type	% of total HLC	No. of sites	% of sites
Ancient Woodland	2.2	6	0.31
Coastal Rough Ground	1.5	25	1.28
Communications	0.4	1	0.05
Dunes	0.3	5	0.26
Farmland C20	10.7	228	11.65
Farmland Medieval	52.2	1175	60.04
Farmland Post Medieval	15.9	243	12.42
Farmland Prehistoric	2.75	148	7.56
Industrial: Disused	0.4	2	0.10
Industrial: Working	0.2	0	0
Military	0.6	6	0.31
Ornamental	1.4	17	0.87
Plantation and Scrub	3.6	21	1.07
Recreational	0.6	11	0.56

Rough Ground/Industrial	0.1	2	0.10
Settlement C20	3.1	33	1.69
Settlement older core (pre-1907)	0.5	5	0.26
Upland Rough Ground	2.8	26	1.33
Water: Natural	0.6	2	0.10
Water: Reservoirs	0.1	1	0.05
Total number of sites		1957	

Table 3. Distribution of rounds and enclosures within each HLC Type

More than 60% of rounds and enclosures are found in the Farmland Medieval HLC Type. In fact nearly 70% are located in the Anciently Enclosed Land HLC Zone (AEL, comprising Farmland Medieval and Farmland Prehistoric), which is an entirely expected pattern. Also expected is the fact that less than a quarter are located in Recently Enclosed Land (comprising Farmland Post medieval and Farmland C20).

5.3.2 Prehistoric field systems

Site type: Field systems			
HLC Type	% of total HLC	No. of sites	% of sites
Ancient Woodland	2.2	0	0
Coastal Rough Ground	1.5	50	9.45
Communications	0.4	0	0
Dunes	0.3	7	1.32
Farmland C20	10.7	61	11.53
Farmland Medieval	52.2	246	46.5
Farmland Post Medieval	15.9	44	8.32
Farmland Prehistoric	2.75	86	16.26
Industrial: Disused	0.4	1	0.19
Industrial: Working	0.2	0	0
Military	0.6	0	0
Ornamental	1.4	0	0
Plantation and Scrub	3.6	4	0.76
Recreational	0.6	0	0
Rough Ground/Industrial	0.1	1	0.19
Settlement C20	3.1	4	0.76
Settlement older core (pre-1907)	0.5	0	0
Upland Rough Ground	2.8	25	4.73
Water: Natural	0.6	0	0
Water: Reservoirs	0.1	0	0
Total number of sites		529	

Table 4. Distribution of field systems within each HLC Type

The ratio of field systems in AEL to those in REL (62%/19% = 3.2) is broadly similar to that of rounds/enclosures (70%/24% = 2.9) although only 46% of the field systems are located in Farmland Medieval (as opposed to 60% of rounds). A significant difference between the distribution of field systems and enclosures/rounds is the proportion of sites located in Rough Ground HLC Types; 14% of field systems as opposed to 2.6% of enclosures. This is somewhat surprising as it might be expected that field distribution would closely resemble settlement distribution (as indicated by the location of rounds and enclosures). The majority of the Rough Ground field systems are within Coastal Rough Ground and they probably represent survival of boundaries extending from AEL into the coastal zone. This is suggested by the relatively high number of sites in the Farmland Prehistoric HLC Type, which is confined to West Penwith where fields extending onto the cliff tops are well-known (e.g. Herring 2008).

5.3.3 Open settlements

Site type: Hut circles/Round houses			
HLC Type	% of total HLC	No. of sites	% of sites
Ancient Woodland	2.2	1	0.35
Coastal Rough Ground	1.5	58	20.14
Communications	0.4	0	0.00
Dunes	0.3	7	2.43
Farmland C20	10.7	27	9.38
Farmland Medieval	52.2	55	19.1
Farmland Post Medieval	15.9	40	13.89
Farmland Prehistoric	2.75	33	11.46
Industrial: Disused	0.4	0	0
Industrial: Working	0.2	0	0
Military	0.6	8	2.78
Ornamental	1.4	1	0.35
Plantation and Scrub	3.6	7	2.43
Recreational	0.6	1	0.35
Rough Ground/Industrial	0.1	0	0
Settlement C20	3.1	14	4.86
Settlement older core (pre-1907)	0.5	1	0.35
Upland Rough Ground	2.8	34	11.81
Water: Natural	0.6	1	0.35
Water: Reservoirs	0.1	0	0
Total number of sites		288	

Table 5. Distribution of hut circles and round houses within each HLC Type

Almost 90% of the hut circles survive with extant remains and this influences their distribution. One third are located in Rough Ground (Coastal and Upland Rough Ground), and only 30% in AEL, where intensive ploughing has destroyed traces of former settlements. A similar proportion of hut circles to rounds (23 – 24%) are located in REL.

5.3.4 Bronze Age barrows

Site type: Barrows			
HLC Type	% of total HLC	No. of sites	% of sites
Ancient Woodland	2.2	1	0.05
Coastal Rough Ground	1.5	114	5.38
Communications	0.4	2	0.09
Dunes	0.3	7	0.33
Farmland C20	10.7	324	15.28
Farmland Medieval	52.2	684	32.26
Farmland Post Medieval	15.9	633	29.86
Farmland Prehistoric	2.75	83	3.92
Industrial: Disused	0.4	4	0.19
Industrial: Working	0.2	0	0
Military	0.6	15	0.71
Ornamental	1.4	18	0.85
Plantation and Scrub	3.6	41	1.93
Recreational	0.6	22	1.04
Rough Ground/Industrial	0.1	19	0.90
Settlement C20	3.1	59	2.78
Settlement older core (pre-1907)	0.5	0	0
Upland Rough Ground	2.8	85	4.01
Water: Natural	0.6	8	0.38
Water: Reservoirs	0.1	1	0.05
Total number of sites		2120	

Table 6. Distribution Bronze Age barrows within each HLC Type

In contrast to settlement features such as enclosures, more barrows are located in REL (45%) than in AEL (36%), with 10% in Rough Ground, and the ratio of sites in AEL to sites in REL = 0.8. Even so the largest number of barrows is found in the Farmland Medieval HLC Type.

5.3.5 Iron Age hillforts

Site type: Hillforts			
HLC Type	% of total HLC	No. of sites	% of sites
Ancient Woodland	2.2	4	4.6
Coastal Rough Ground	1.5	1	1.15
Communications	0.4	0	0
Dunes	0.3	1	1.15
Farmland C20	10.7	6	6.9
Farmland Medieval	52.2	44	50.57
Farmland Post Medieval	15.9	10	11.49
Farmland Prehistoric	2.75	3	3.45
Industrial: Disused	0.4	0	0
Industrial: Working	0.2	0	0
Military	0.6	0	0
Ornamental	1.4	1	1.15
Plantation and Scrub	3.6	4	4.6
Recreational	0.6	1	1.15
Rough Ground/Industrial	0.1	0	0
Settlement C20	3.1	3	3.45
Settlement older core (pre-1907)	0.5	2	2.3
Upland Rough Ground	2.8	7	8.05
Water: Natural	0.6	0	0
Water: Reservoirs	0.1	0	0
Total number of sites		87	

Table 7. Distribution hillforts within each HLC Type

More than half the hillforts are located in the HLC Type Farmland medieval and the ratio of hillforts in AEL to those in REL is $54\%/18\% = 3.0$, which is broadly similar to that of rounds and enclosures (2.9). However, the general distribution of hillforts is more evenly spread than that of rounds and enclosures.

5.3.6 Early medieval sites

Site type: Early medieval sites			
HLC Type	% of total HLC	No. of sites	% of sites
Ancient Woodland	2.2	4	0.19
Coastal Rough Ground	1.5	27	1.28
Communications	0.4	13	0.61
Dunes	0.3	40	1.89
Farmland C20	10.7	106	5.01
Farmland Medieval	52.2	1267	59.88
Farmland Post Medieval	15.9	91	4.3
Farmland Prehistoric	2.75	134	6.33
Industrial: Disused	0.4	2	0.09
Industrial: Working	0.2	0	0
Military	0.6	11	0.52
Ornamental	1.4	58	2.74
Plantation and Scrub	3.6	40	1.89
Recreational	0.6	16	0.76
Rough Ground/Industrial	0.1	0	0
Settlement C20	3.1	234	11.06
Settlement older core (pre-1907)	0.5	49	2.32
Upland Rough Ground	2.8	19	0.9
Water: Natural	0.6	5	0.24
Water: Reservoirs	0.1	0	0
Total number of sites		2116	

Table 8. Distribution Early medieval sites within each HLC Type

Not surprisingly a huge majority of early medieval sites are located in settlement HLC Types or in Farmland medieval (73% of the total). Only 9% of the sites are located in REL (a ratio of AEL/REL of 9.0).

5.3.7 Prehistoric find spots

Pre-Iron Age find spots

Site type: Prehistoric finds			
HLC Type	% of total HLC	No. of sites	% of sites
Ancient Woodland	2.2	10	0.76
Coastal Rough Ground	1.5	131	9.95
Communications	0.4	4	0.3
Dunes	0.3	14	1.06
Farmland C20	10.7	171	12.99
Farmland Medieval	52.2	325	24.7
Farmland Post Medieval	15.9	212	16.11
Farmland Prehistoric	2.75	228	17.33
Industrial: Disused	0.4	7	0.53
Industrial: Working	0.2	2	0.15
Military	0.6	6	0.46
Ornamental	1.4	11	0.84
Plantation and Scrub	3.6	15	1.14
Recreational	0.6	4	0.3
Rough Ground/Industrial	0.1	1	0.08
Settlement C20	3.1	80	6.08
Settlement older core (pre-1907)	0.5	13	0.99
Upland Rough Ground	2.8	68	5.17
Water: Natural	0.6	8	0.61
Water: Reservoirs	0.1	6	0.46
Total number of sites		1316	

Table 9. Distribution pre-Iron Age findspots within each HLC Type

The table above shows all prehistoric finds (periods: Palaeolithic, Mesolithic, Neolithic, 'Prehistoric' and 'Unknown' where the objects found are clearly prehistoric) where the dataset has been reduced to one PRN per record. More finds are located in Farmland medieval than any other HLC Type; 42% of the finds are located in AEL, 29% in REL and 15% in Rough Ground Types.

Iron Age and Romano-British find spots

Site type: IA/RB finds			
HLC Type	% of total HLC	No. of sites	% of sites
Ancient Woodland	2.2	5	1.54
Coastal Rough Ground	1.5	37	11.38
Communications	0.4	0	0
Dunes	0.3	12	3.69
Farmland C20	10.7	23	7.08
Farmland Medieval	52.2	99	30.46
Farmland Post Medieval	15.9	30	9.23
Farmland Prehistoric	2.75	41	12.62
Industrial: Disused	0.4	2	0.62
Industrial: Working	0.2	0	0
Military	0.6	0	0
Ornamental	1.4	5	1.54
Plantation and Scrub	3.6	6	1.85
Recreational	0.6	8	2.46
Rough Ground/Industrial	0.1	0	0
Settlement C20	3.1	27	8.31
Settlement older core (pre-1907)	0.5	10	3.08
Upland Rough Ground	2.8	14	4.31
Water: Natural	0.6	5	1.54
Water: Reservoirs	0.1	1	0.31
Total number of sites		325	

Table 10. Distribution Iron Age and Romano-British findspots within each HLC Type

Roughly a third of Iron Age/Romano-British finds have been made in the HLC Type Farmland medieval. A similar percentage to that of pre-Iron Age finds have been made in AEL (43% as opposed to 42%), but fewer have been made in REL (16% as opposed to 25%), and a similar percentage of Iron Age/Romano-British finds are located in REL and Rough Ground Types.

5.3.8 Portable Antiquities Scheme find spots

Site type: PAS data			
HLC Type	% of total HLC	No. of sites	% of sites
Ancient Woodland	2.2	5	2.16
Coastal Rough Ground	1.5	4	1.73
Communications	0.4	1	0.43
Dunes	0.3	16	6.93
Farmland C20	10.7	6	2.60
Farmland Medieval	52.2	105	45.45
Farmland Post Medieval	15.9	50	21.65
Farmland Prehistoric	2.75	37	16.02
Industrial: Disused	0.4	0	0
Industrial: Working	0.2	0	0
Military	0.6	0	0
Ornamental	1.4	1	0.43
Plantation and Scrub	3.6	0	0
Recreational	0.6	0	0
Rough Ground/Industrial	0.1	0	0
Settlement C20	3.1	1	0.43
Settlement older core (pre-1907)	0.5	0	0.00
Upland Rough Ground	2.8	4	1.73
Water: Natural	0.6	1	0.43
Water: Reservoirs	0.1	0	0
Total number of sites		231	

Table 11. Distribution Portable Antiquity Scheme findspots within each HLC Type

Almost half of PAS finds are located in Farmland medieval and 61% of the finds have been made in AEL. Twenty four percent of PAS finds come from REL and only slightly more than 3% from Rough Ground.

6 Significance testing

6.1 Methodology

6.1.1 The χ^2 test

The first step in creating viable models from the site data discussed in the previous sections is to establish that the distributions apparent from the data analysis are statistically significant; that is that they are not merely representing by-chance patterns. For instance, the fact that there are more rounds in the Farmland Medieval HLC Type than in any other 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 χ^2 test (or Chi-Squared test) was used. χ^2 is a standard statistical procedure (Lowry 2009). It was first suggested for use in archaeological predictive modelling projects by Hodder and Orton (1976) and has been commonly applied since. It measures the degree to which the actual (or observed) distribution pattern differs from the expected pattern in the aggregate. It does this by taking the squared difference between the observed frequency and its corresponding expected frequency and dividing this figure by the expected frequency:

$(O-E)^2/E$, where O = observed frequency and E = expected frequency.

In calculating expected frequency 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 the 'null hypothesis'. Thus if an HLC Type covers 25% of the project area, the null hypothesis holds that the expected frequency of sites in that Type = 25% of the total number of sites in the project area. χ^2 values are calculated for each HLC Type and the aggregate χ^2 value equals the sum of all the individual values; so $\chi^2 = \sum (O-E)^2/E$.

The Chi-Squared test for field systems below (table 12) serves as an example. The χ^2 value for each HLC Type is shown in the far right hand column and the sum of these values shown in bold as the χ^2 value, which in this case = 647.79.

It should be noted that all the HLC Types for which the expected number of sites is less than five have been grouped together as 'Other'. This is because the logical validity of the χ^2 test is greatest when the values of E – the expected frequencies – are large and decreases as the values of E become smaller. The generally accepted practice is that Chi-Squared procedures can only be legitimately applied if all values of E are equal to or greater than 5. Similarly the validity of Chi-Squared procedures is less assured if the number of observations falls below a certain level. For this reason HLC Types in which the number of sites observed is less than 40 have not been included in the models. This precludes building a model for the site type 'cemetery' for which only 19 records are listed in the project dataset.

The next stage in the Chi-Squared procedure is to calculate how likely it is that this or any other random sample of 529 field systems might end up with a discrepancy between the observed and expected frequencies this large or larger (that is, with a calculated χ^2 value equal to or greater than 647.79).

Using the CHI_INV facility in Excel the critical value of Chi-Squared for significance at the P=.05 level was computed as $\chi^2=19.6752$. This means that of all possible values of Chi-Squared that might have resulted in this situation (based on the null hypothesis assumption that proportion of sites in each HLC Type would equal the proportion of area taken up by that HLC Type) only 5% would have been equal to or greater than 19.6752.

The observed χ^2 value of 647.79 is much larger than this critical value: therefore for field systems we can say that the calculated value of χ^2 is well beyond the .05 level. In fact what this calculation tells us is that the probability of the observed distribution of

field systems within the various HLC Types representing a by chance pattern is considerably less than 5%.

Field systems				
HLC Type	Area km2	Sites	Expected	Chi-Squared
Farmland Medieval	1663.6387	246	275.8966	3.2397
Farmland Post medieval	510.1570	44	84.6041	19.4871
Farmland C20	343.1721	61	56.9114	0.2937
Plantation and Scrub	115.3667	4	19.1323	11.9686
Settlement C20	98.4645	4	16.3293	9.3091
Upland Rough Ground	90.4460	25	14.9995	6.6676
Farmland Prehistoric	87.6498	86	14.5358	351.3494
Ancient Woodland	71.1736	0	11.8034	11.8034
Coastal Rough Ground	48.2021	50	7.9938	220.7364
Ornamental	43.7870	0	7.2616	7.2616
Other (Expected<5)	117.7781	9	19.5322	5.6792
Chi-Sq Value				647.7959
<i>Other HLC Types</i>				
<i>Industrial: Working</i>	5.0147	0	0.8316	
<i>Rough Ground/Industrial</i>	3.6882	1	0.6116	
<i>Water: Reservoirs</i>	2.8784	0	0.4773	
<i>Recreational</i>	19.8541	0	3.2926	
<i>Water: Natural</i>	18.7553	0	3.1104	
<i>Military</i>	17.6506	0	2.9272	
<i>Settlement older core (pre- 1907)</i>	16.6477	0	2.7608	
<i>Communications</i>	13.2478	0	2.1970	
<i>Industrial: Disused</i>	11.4362	1	1.8966	
<i>Dunes</i>	8.6051	7	1.4271	
5% Significance Chi-Sq Value =				19.6752

Table 12. Results of Chi-Squared testing the correlation of prehistoric field systems with HLC Types.

6.2 Results of χ^2 testing

The results of the Chi-Squared tests carried out during the project are summarised below in table 13. The full results of the tests are presented in Appendix 1.

Site type	5% Significance value	Chi-sq value
Rounds and enclosures	28.869	330.488
Field systems	19.675	647.796
Hut circles/round houses	16.919	409.760
Barrows	28.869	409.760
Hillforts	9.488	6.424
Early medieval sites	28.869	1274.698
PA – BA find spots	26.296	1966.490
IA/RB find spots	12.592	393.766
PAS find spots	15.507	187.566

Table 13. Results of Chi-Squared testing the correlation of all site types with HLC Types.

In Chi-Squared tests on all the site types except hillforts the null hypothesis was rejected. In fact Chi-Squared testing for all other site types produced very high χ^2 values leading to questions regarding the validity of the procedure. The great disparity in size among the various HLC Types seemed the most likely cause of these concerns. For instance Coastal Rough Ground covers only 48 km sq as opposed to Farmland Medieval which covers 1,663. This disparity might mean that the number of eventualities possible for random distribution samples may be beyond the realistic computing capabilities of the CHI_DIST function.

For this reason a series of secondary tests was run. For these tests the various HLC Types were grouped together into higher level cells so that there would be fewer variables and the number of expected sites per cell would be higher than when testing the 20 individual HLC Types. One obvious means of grouping the types was to use HLC Zones as the variables. However if HLC Zones were used instead of HLC Types there would still be 15 variables (there are 15 HLC Zones) and the size disparity would be even greater (for instance the HLC Zone Dunes is exactly the same as the HLC Type Dunes and covers 8.6 km sq, whereas the HLC Zone Anciently Enclosed Land covers 1,751 km sq). To overcome this, the following groupings or character areas were defined:

Character Area	Includes HLC Types	Area km sq
Anciently Enclosed Land	Farmland Medieval Farmland Prehistoric	1751.288
Recently Enclosed Land	Farmland C20 Farmland Post Medieval	853.329
Rough Ground	Upland Rough Ground Rough Ground/Industrial	94.134
Woodland	Ancient Woodland Plantation and Scrub	186.540
Settlement	Settlement C20 Settlement older core	115.112
Coastal	Coastal Rough Ground	75.562

	Dunes Water Natural	
Imposed	Communications Industrial: Disused Industrial: Working Military Ornamental Recreational Water: Reservoirs	113.868

The character area 'Imposed' includes those HLC Types which might be seen as having been imposed on the landscape which would have previously been of a different HLC Type. For instance a golf course, characterised as Recreational, may have been laid out in the 1950s in an area of Farmland Medieval, or a military airfield constructed in an area of Farmland Post Medieval in 1941. Industrial activity, particularly from the eighteenth century onwards, again will have altered previous HLC.

Although the HLC Type Water Natural does include some inland pools, all sites located within the type are found along the coast and, for this reason, it has been included in the Coastal character area.

Although there does remain a significant size disparity between some of the character areas, they represent the broadest groupings attainable without reducing the integrity of HLC. The Chi-Squared test for field systems is shown below.

Field systems				
Character area	Area km2	Sites	Expected	Chi-Squared
Anciently enclosed land	1751.2884	332	290.4324	5.9493
Recently enclosed land	853.3290	105	141.5155	9.4221
Rough Ground	94.1341	26	15.6111	6.9136
Woodland	186.5403	4	30.9357	23.4529
Settlement	115.1122	4	19.0901	11.9283
Coastal	75.5625	57	12.5312	157.8036
Imposed	113.8688	1	18.8839	16.9369
Chi-Sq Value				232.4066
5% Significance Chi-Sq Value =				14.0671

Table 14. Results of Chi-Squared testing the correlation of prehistoric field systems with amalgamated HLC Types.

The results of this test indicate that the calculated value of χ^2 is well beyond the .05 level and it is likely that there is a significant correlation between the distribution of field systems and the character areas. This suggests in turn that the Chi-Squared test for field systems and HLC Types can be accepted. The results of the Chi-squared tests carried out using the high level character areas are summarised below. The full results of the tests are presented in Appendix 1.

Site type	5% Significance value	Chi-sq value
Rounds and enclosures	14.067	178.963
Field systems	14.067	232.407
Hut circles/round houses	14.067	628.927
Barrows	14.067	615.083
Early medieval sites	14.067	948.174
PA – BA find spots	14.067	621.733
IA/RB find spots	14.067	361.510
PAS find spots	14.067	64.134

Table 14. Results of Chi-Squared testing the correlation of all site types with amalgamated HLC Types.

7 Building the high level models

Having established, through Chi-Squared testing, that there is a statistically significant correlation between site distribution and HLC Types for all relevant site types except hillforts, predictive models were then built as the next stage of the project. Because the null hypothesis was not rejected in the test for hillforts, no model for hillforts was attempted.

7.1 Predictive modelling; theory and practice

Archaeological predictive modelling is a technique used to identify potential site locations on the basis of assumptions about human behaviour, on the premise that certain portions of the landscape were more attractive for human activity than others. Broadly speaking, two different approaches to predictive modelling have been practised, usually referred to as 'inductive' and 'deductive'. In the inductive approach the model is based on the correlation of known archaeological sites with attributes from the current physical landscape. The deductive approach starts with theoretical knowledge concerning human behaviour and uses this to define those environmental variables likely to have conditioned the choice of activity locations; a sample of known sites is then used to evaluate the model.

The modelling carried out during the Lowland Cornwall project was inductive, correlating known prehistoric sites with HLC attributes.

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. The quadrats are transferred to grid cells in a raster GIS and the modelling results in a 'site likely' model and a 'site unlikely' model. 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 recent critical review of Dutch predictive modelling techniques published by Philip Verhagen of Leiden University (Verhagen 2007).

The variables considered in predictive models are usually a combination of factors of the natural environment (elevation, distance from water, slope gradient geology, soil type etc.). A common criticism of this sort of archaeological predictive modelling is that it is environmentally deterministic – that past human behaviour cannot be understood simply in terms of environment and economy, but that social and cultural factors have a significant influence on this behaviour (e.g. Wheatley 2003; Kohler 1988).

In his review of Dutch predictive modelling, Verhagen addressed this issue and identified four cultural variables that are significant for archaeological site location (Verhagen 2007, 207). Two of these are central to the methodology of the Lowland Cornwall project (*ibid*):

- The continuity of the cultural landscape
 - *'The cultural landscape has a historical dimension that strongly influences its use and usability. The existing cultural landscape strongly influences the positioning of new sites. Kuna (1998), for example, mentions the importance of remnants of past landscapes on settlement location choice'.*
- A systematic analysis of the archaeological records and their aggregation into culturally meaningful entities.
 - *'... By combining multiple archaeological sites into ensembles, which effectively constitutes a step away from the site level and towards a regional landscape-based concept of archaeological entities (see also Kuna 2000).'*

With regard to the second point, Verhagen recommends the aggregation of find spots into meaningful archaeological entities and identifies the aggregation of multiple find spots into single archaeological sites as an important issue. Whilst this is clearly a desirable objective, a large amount of research and analysis would be required to achieve this objective in Cornwall. Given the resources available to the Lowland Cornwall project, such an undertaking was not possible (see section 5.1.4).

Notwithstanding issues regarding find spots, the modelling carried out in the Lowland Cornwall project was based primarily on cultural rather than environmentally deterministic variables and, in this respect, can be seen as somewhat experimental. 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. a precursor settlement). 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. The basic premise of the Lowland Cornwall project is that this zone is where we are most likely to find prehistoric and Romano-British farms and settlements.

7.2 Constructing the models

7.2.1 Clarification of terms, gain measures and formulae

The χ^2 test (section 6.1.1) is useful for establishing whether statistically significant patterns between site location and HLC Types can be observed. However χ^2 is intrinsically non-directional: it 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 (specifically those used in the Lowland Cornwall project) are outlined below.

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 Lowland Cornwall 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.

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 and it was used to create the Indicative Map of Archaeological Values in the Netherlands (Deeben *et al* 1997). 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 (Wansleebe and Verhart 1992). 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 high level predictive models for Lowland Cornwall used point data for sites rather than areas 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 (Wansleebe and Verhart 1992).

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.

It is important to note that whereas Indicative Value, S/A and Kj parameter are used to rank each zone of interest in order of importance (basically they are used to construct the model) Relative Gain, Kvamme's Gain and other gain measures are 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 10 below.

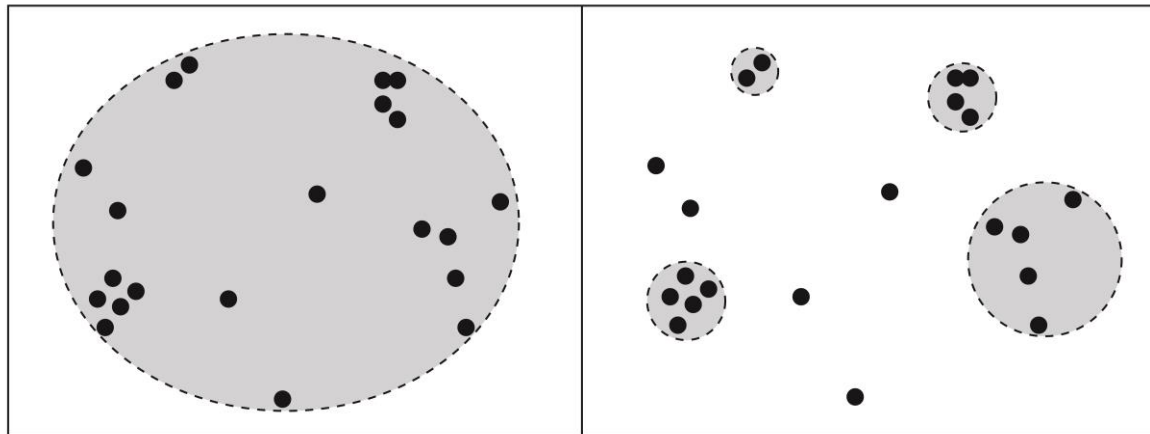


Fig 10. The difference between accuracy and precision.

The model to the left 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. After Verhagen 2007, Figure 7.1

These two factors, Accuracy and Precision, together determine the performance of the model. With a three-zone model (such as those produced during this project) Accuracy and Precision can be determined for each zone 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 this balance was difficult to achieve in the Lowland Cornwall project and 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.

7.2.2 Constructing a model using Indicative Values

Understanding the stages and method of constructing predictive models and why the Kj Parameter was chosen as the most appropriate formula can best be outlined by presenting an actual example. This section outlines the method for building a model for prehistoric field systems using Indicative Values (PS/PA) as the formula for defining importance.

Looking first at the distribution pattern for prehistoric field systems, the relative importance of each HLC Type according to its Indicative Value (PS/PA) is set out in the table below in descending order of importance. An attempt has been made to categorise the HLC Types into areas of high, medium and low probability, where high probability areas contain more sites than expected and low probability areas contain fewer sites than expected. The criteria used in this instance to define the cut-off points between the three zones are: high probability, $PS/PA > 2.0$; medium probability $> 1.0 < 2.0$; low probability < 1.0 .

Field systems. High probability zone					
HLC Type	Area km2	Sites	PA	PS	PS/PA
Coastal Rough Ground	48.20	50	0.0151	0.0945	6.2549
Farmland Prehistoric	87.65	86	0.0275	0.1626	5.9164
Dunes	8.61	7	0.0027	0.0132	4.9052
Field systems. Medium probability zone					
HLC Type	Area km2	Sites	PA	PS	PS/PA
Upland Rough Ground	90.45	25	0.0284	0.0473	1.6667
Rough Ground/Industrial	3.69	1	0.0012	0.0019	1.6349
Farmland C20	343.17	61	0.1076	0.1153	1.0718
Field systems. Low probability zone					
HLC Type	Area km2	Sites	PA	PS	PS/PA
Farmland Medieval	1663.64	246	0.5215	0.4650	0.8916
Industrial: Disused	11.44	1	0.0036	0.0019	0.5273
Farmland Post Medieval	510.16	44	0.1599	0.0832	0.5201
Settlement C20	98.46	4	0.0309	0.0076	0.2450
Plantation and Scrub	115.37	4	0.0362	0.0076	0.2091
Water: Reservoirs	2.88	0	0.0009	0	0
Industrial: Working	5.01	0	0.0016	0	0
Communications	13.25	0	0.0042	0	0
Settlement older core	16.65	0	0.0052	0	0
Military	17.65	0	0.0055	0	0
Water: Natural	18.76	0	0.0059	0	0
Recreational	19.85	0	0.0062	0	0
Ornamental	43.79	0	0.0137	0	0
Ancient Woodland	71.17	0	0.0223	0	0
Totals:	3189.84	529	1.0	1.0	

Table 15. Model for prehistoric field systems based on Indicative Values.

Assuming for the moment that the field systems model outlined in the Indicative Values tables above is correct, its performance can be assessed using gain measures. If the model is performing well, the high probability zone will have high gain values, the low probability zone will have low gain values and the gain values for the medium probability zone will lie somewhere in between. The Kvamme's gain measures for each of the three zones are shown in the table below.

Probability	PS	PA	Kvamme's gain
High	0.27	0.04	0.8324
Medium	0.16	0.14	0.1664
Low	0.57	0.82	-0.4465

Table 16. Performance of the Indicative Values field systems model.

In theory a good predictive model should contain the largest possible proportion of sites in the smallest possible proportion of the study area. In practice, however, this does not necessarily produce the best practical model. In this model, although the high probability area covers only 4% of the project area, resulting in a very high Kvamme's

gain, only 27% of the sites are captured within it, and 57% of the sites are in the area of low probability. So although the model is precise (because the high probability zone is small) it is clearly not at all accurate (because it does not contain the majority of the sites).

Looking at the table of Indicative Values above the reason for this is immediately apparent. The measure of Indicative Value does not provide a relative weighting of the HLC Types according to their size. There are two unsatisfactory outcomes to this failure. Firstly, small HLC Types which contain only a few sites have a higher Indicative Value than large Types containing many sites, even though the Type containing many sites can be considered archaeologically more important. A very clear example of this is Rough Ground/Industrial (containing one site) producing a higher Indicative Value than Farmland Medieval (containing 246 sites). Secondly, although a large HLC Type without any sites is statistically more significant than a small Type without sites (because it is less 'important' for site location than a smaller Type), in the table all these Types have an Indicative Value of 0, and are thereby attributed equal importance. An example of this is Ancient Woodland, which covers 71 km sq, as opposed to Industrial: Working, which only covers 5 km sq.

7.2.3 Constructing a model using the Kj parameter

In order to account for this lack of weighting a number of techniques have been used (e.g. Atwell and Fletcher 1985, 1987; Wansleebe and Verhart 1992). The method applied during the Lowland Cornwall project is the Kj parameter, developed by Wansleebe and Verhart (1992). The measure is defined as: $\sqrt{(PS \times (PS-PA)/PW)}$. The advantage of this calculation lies in the fact that its extra PS factor and negative PA weighting means that it favours larger areas over smaller areas that might have the same Kvamme's Gain.

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 (Wansleebe and Verhart 1992).

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.

Kj for Types with a negative Relative Gain ($PS-PA < 0$) cannot immediately be calculated so they are ignored at each stage until enough of the project area has been excluded that their gain measure within the remaining area is positive. This means that such landscape types will be ranked much later in the process. It also means that HLC Types with no sites will nonetheless be ranked (according to size) which is a better outcome than that produced by the use of Indicative Values.

Field systems. High probability zone				
Rank	HLC Type	Sites	Kj cum	Kvamme's gain
1	Farmland Prehistoric	86	0.1482	0.8310
2	Coastal Rough Ground	50	0.2348	0.8343
3	Farmland Medieval	246	0.3378	0.2188
4	Farmland C20	61	0.3725	0.1979
5	Upland Rough Ground	25	0.4041	0.2087
Field systems. Medium probability zone				
Rank	HLC Type	Sites	Kj cum	Kvamme's gain
6	Farmland Post Medieval	44	0.3231	0.1114
7	Dunes	7	0.3408	0.1207
8	Settlement C20	4	0.3066	0.0962
Field systems. Low probability zone				
Rank	HLC Type	Sites	Kj cum	Kvamme's gain
9	Plantation and Scrub	4	0.2574	0.0667
10	Rough Ground/Industrial	1	0.2590	0.0673
11	Industrial: Disused	1	0.2560	0.0655
12	Ancient Woodland	0	0.2079	0.0432
13	Communications	0	0.1976	0.0391
14	Industrial: Working	0	0.1936	0.0375
15	Military	0	0.1788	0.0320
16	Ornamental	0	0.1350	0.0182
17	Recreational	0	0.1095	0.0120
18	Settlement older core	0	0.0824	0.0068
19	Water: Natural	0	0.0300	0.0009
20	Water: Reservoirs	0	0	0

Table 17. Predictive model for prehistoric field systems based on the Kj parameter.

Table 17 shows a model for prehistoric field systems constructed using Kj parameters. The *Kj cum* column sets out the cumulative Kj values for each HLC Type. As each Type was added to the model according to its rank, the Kj values increase until they reach a maximum of 0.4041 after the five top-ranked Types have been added. These are all HLC Types with a positive Kj value and they form the high probability zone according to this model. The remainder of the HLC Types all reduce the overall Kj value of the model: those which take the overall value below the 0.30 mark have been classed as the low probability zone; those between 0.30 and 0.40 are classed as the medium probability zone.

At face value this seems to be a more satisfactory model. However the column on the right shows the Kvamme's gains for the model on a cumulative basis. As each HLC Type was added to the model so the proportion of sites and proportion of area (PS and PA) for the model as a whole increased. The Kvamme's gain values in this column show that whilst the two top-ranked HLC Types yield high gain measures, as further Types are added the gain measures for the model fall sharply (this is particularly true when the Type Farmland Medieval is added). The gain measures for the model are set out below.

Probability	PS	PA	Kvamme's gain
High	0.88	0.70	0.209
Medium	0.11	0.19	-0.861
Low	0.01	0.11	-8.384

Table 18. Performance of the K_j parameters field systems model.

The performance of this model is quite different from the one based on Indicative Values. Here 88% of the sites are captured in the zone of high probability, but as this covers 70% of the project area it produces a low Kvamme's gain. The zone of medium probability covers 19% of the area and contains 11% of the sites, which is a reasonable performance. The model succeeds best in predicting where few sites are to be found – the zone of low probability covers 11% of the project area but contains only 1% of the sites.

Of the two models created, the Indicative Values model is precise but not accurate; the K_j parameter model is accurate but not precise. The key question is where to place HLC Type Farmland Medieval, because it is classed as high probability in the K_j model but as low probability in the Indicative Values model. A further difficulty is that this particular HLC Type covers more than half of the project area and its placing will therefore have a pronounced effect on overall model performance.

Clearly placing Farmland Medieval in the zone of low probability would produce an inaccurate model as more than half the sites would then be captured in that zone. If the Type is placed in the zone of medium probability then the model will produce good Kvamme's gain measures, shown below:

Probability	PS	PA	Kvamme's gain
High	0.43	0.18	0.581
Medium	0.56	0.71	-0.279
Low	0.01	0.11	-10.084

The zone of high probability performs reasonably well in this model, with 43% of the sites captured within 18% of the project area, as does the zone of low probability (less than 1% of the sites in 11% of the project area). However the zone of medium probability takes up more than 70% of the project area. The zone of medium probability in a three-zone model should in theory have neither many more nor many fewer sites than expected and in this regard can be seen to be little more than a by-chance distribution. This model, because the zone of medium probability is so large, therefore has very little predictive power. The best option therefore is to include Farmland Medieval in the zone of high probability, as it was placed in the K_j model. The downside of this is a Kvamme's gain measure of 0.209 as opposed to 0.581.

During the course of the Lowland Cornwall project it became apparent that the large area covered by the HLC Type Medieval Farmland was a significant and detrimental factor in the performance of many of the models. Its large area (more than 50% of Lowland Cornwall) meant that the models lack precision and are accompanied by low Kvamme's gain measures. However, Kvamme produced models with site-likely and site non-likely zones. Assessment of the performance of these binary models rests entirely on the gain measures achieved by the site-likely zone. In the context of three-zone models a more nuanced assessment of performance is appropriate, whereby the performance of each individual zone can be measured and compared with that of the other two zones. This measure can be achieved by calculating the ratio of Indicative Values (PS/PA) between each probability zone. In the case of the K_j model for prehistoric field systems the Indicative Values are as follows.

Probability	PS	PA	PS/PA
High	0.88	0.70	1.26
Medium	0.11	0.19	0.53
Low	0.01	0.11	0.09

The ratios for each combination of probability zones are therefore as follows (with decimal points rounded up):

High/Medium $1.26/0.53 = 2.4$

High/Low $1.26/0.09 = 14$

Medium/Low $0.53/0.09 = 6$

The model suggests that the likelihood of encountering a prehistoric field system in the high probability zone is almost two and a half times greater than in the medium probability zone and 14 times more likely than in the low probability zone. The chances of encountering a field system in the medium probability zone are six times greater than in the low probability zone. Viewed in this light the performance of the Kj model for prehistoric field systems can be seen as a clear statement of probability, regardless of the fact that the high probability zone produces a low Kvamme's gain measure.

8 The high level models: site types

The previous section examined the rationale behind model construction; this section examines the results of applying this methodology for each of the site types that were considered.

8.1 Field systems

8.1.1 The distribution of prehistoric field systems in lowland Cornwall

The field systems dataset was created by extracting from the HER 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, around the Lizard peninsula and, to a lesser extent the area to the east of Truro. There are several large relatively blank areas (Fig 11).

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 on the Roseland Peninsula, and account for the sites recorded from east Cornwall (Fig 12). Secondly those fields recorded as extant sites. These are concentrated to a large degree in West Penwith (Fig 13). 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).

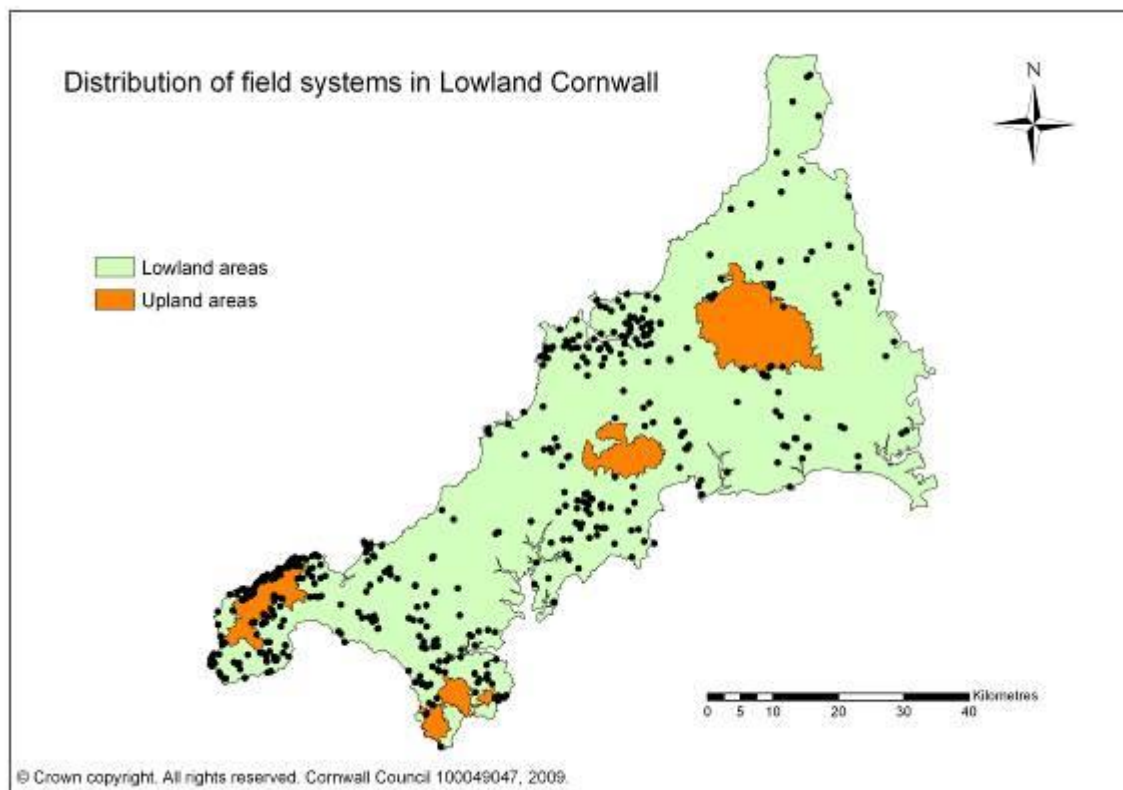


Fig 11. Map showing the distribution of all field systems in the Lowland Cornwall project area.

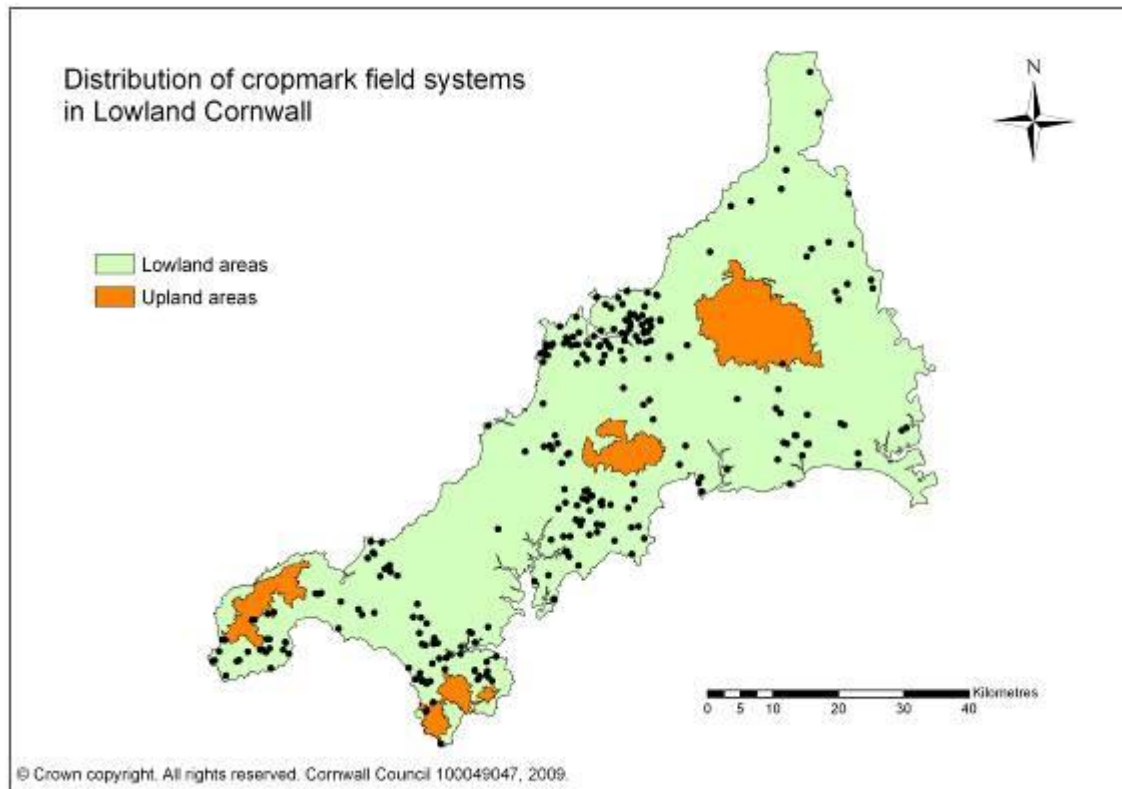


Fig 12. Map showing the distribution of field systems visible as cropmarks in the Lowland Cornwall project area.

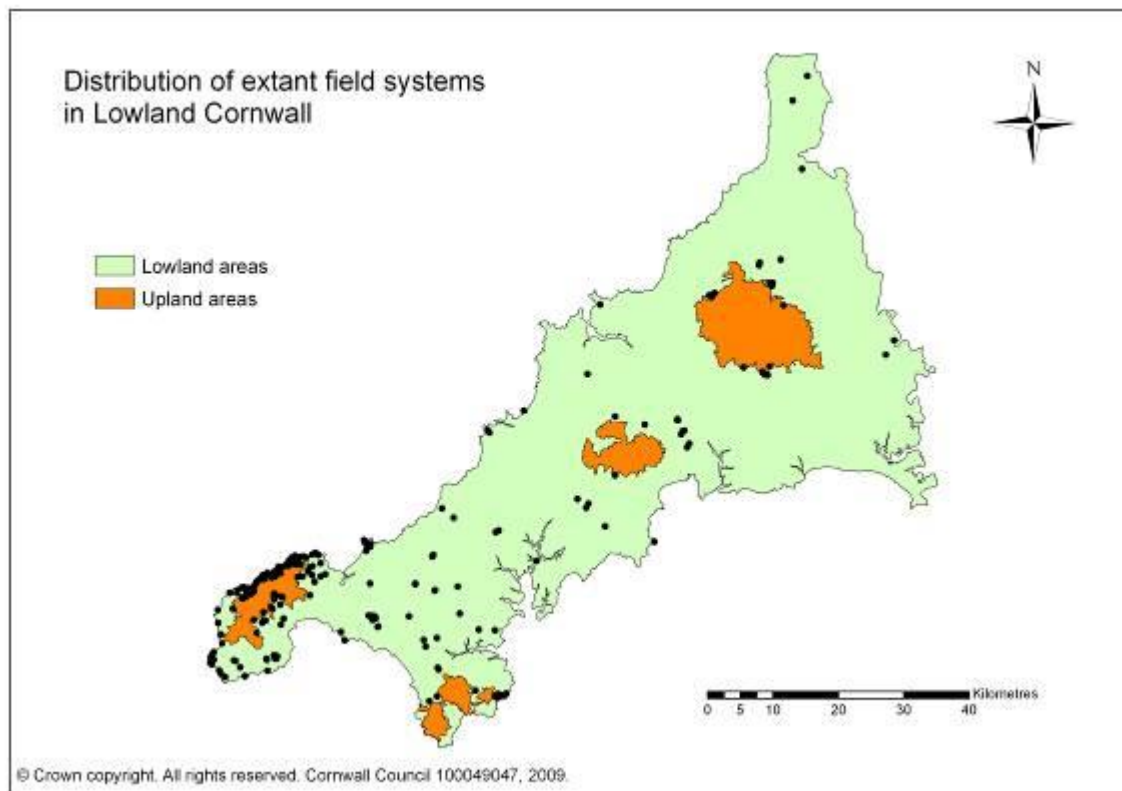


Fig 13. Map showing the distribution of field systems with surviving above-ground remains.

8.1.2 High level model for all recorded field systems

To reiterate the results presented in section 7.2.3, the model for prehistoric field systems is set out below.

Field systems: High probability zone				
HLC Type	Sites	PA	PS	Cum Kj
Farmland Prehistoric	86	0.0275	0.1626	0.1482
Coastal Rough Ground	50	0.0151	0.0945	0.2348
Farmland Medieval	246	0.5215	0.4650	0.3378
Farmland C20	61	0.1076	0.1153	0.3725
Upland Rough Ground	25	0.0284	0.0473	0.4041

Field systems: Medium probability zone				
HLC Type	Sites	PA	PS	Cum Kj
Farmland Post Medieval	44	0.1599	0.0832	0.3231
Dunes	7	0.0027	0.0132	0.3408
Settlement C20	4	0.0309	0.0076	0.3066

All other HLC Types make up the low probability zone. The performance of the model is summarised below.

Probability zone	PA	PS	Kvamme's gain	PS/PA
High	0.70	0.88	0.2087	1.26
Medium	0.19	0.11	-0.8611	0.53
Low	0.11	0.01	-8.3837	0.09

The model is accurate in that 88% of the sites are captured in the high probability zone but lacks precision in that 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). A probability map based on the model is shown in Fig 14.

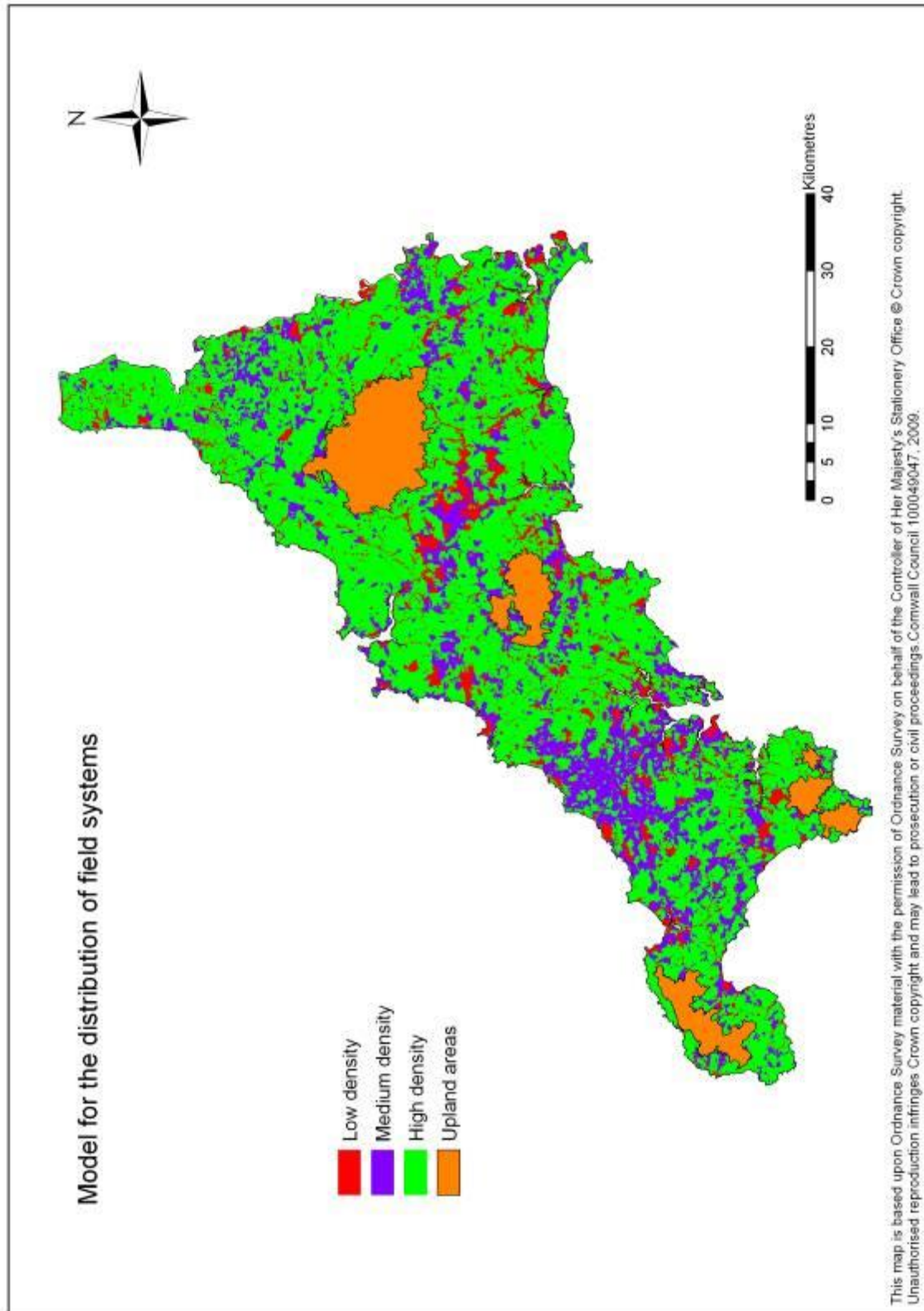


Fig 14. Probability map based on the high level HLC model for prehistoric field systems in Lowland Cornwall.

The dataset is made up almost exclusively of field systems whose form is either cropmark or extant (earthworks); very few field systems are recorded as 'site of' or from documentary evidence. The ratio of cropmark sites to extant is close to 50:50.

Zone	Cropmark	Extant	Documentary	Site of	Total	Percent
High	256	205	3	4	468	88%
Medium	30	24	0	1	55	11%
Low	0	6	0	0	6	1%
Total	286	235	3	5	529	
Percent	54%	44.5%	0.5%	1%		

Table 19. Breakdown of field systems based on form of remains within each probability zone of the model.

The high probability zone of the model is populated by HLC Types characterised both by large numbers of cropmarks and also by Types characterised by large numbers of extant sites (the zone contains 90% of all cropmark sites and 87% of all extant sites).

However, 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 noted above is neutralised and this may have implications for the reliability of the model. For this reason two additional models were developed; for cropmark and for extant field systems.

8.1.3 High level model for cropmark 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).

Cropmark field systems: High probability zone				
HLC Type	Sites	PA	PS	Cum Kj
Farmland Medieval	198	0.5215	0.6923	0.3438
Farmland C20	38	0.1076	0.1329	0.4022
Farmland Prehistoric	19	0.0275	0.0664	0.4577
Cropmark field systems: Medium probability zone				
HLC Type	Sites	PA	PS	Cum Kj
Farmland Post Medieval	29	0.1599	0.1014	0.4186

Table 20. Predictive model for prehistoric field systems based on the correlation of cropmark field systems with HLC Types.

The table below summarises the performance of this model.

Probability zone	PA	PS	Kvamme's gain	PS/PA
High	0.66	0.89	0.2636	1.35
Medium	0.16	0.10	-0.5773	0.63
Low	0.18	0.01	-25.2353	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 slightly higher than that achieved by the model based on all field systems.

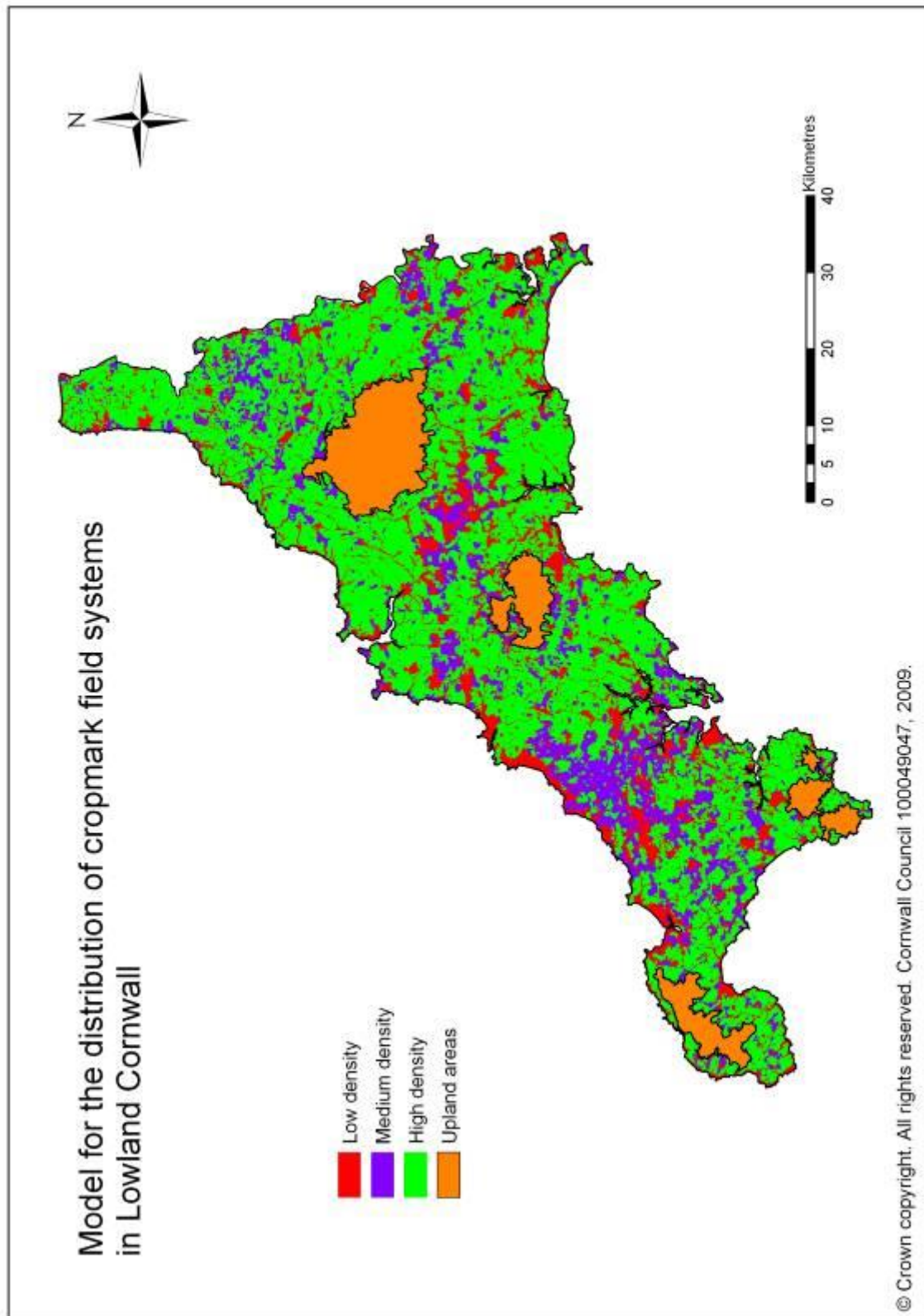


Fig 15. Probability map based on the high level HLC model for cropmark prehistoric field systems in Lowland Cornwall.

In fact the performance of this model is quite similar to that for all field systems although, of course, the HLC Types are ranked rather differently. The probability map resulting from this model is also similar to that for field systems generally (Fig 14).

What the model does tell us is that, based on the ratio of Indicative Values, one is roughly twice as likely to encounter a cropmark prehistoric field system in the high probability zone as in the medium zone and 27 times more likely than in the low probability zone. One is 12.5 times more likely to encounter a cropmark field system in the medium probability zone as in the low zone.

8.1.4 High level model for extant field systems

The results are very different in the model for extant sites which is summarised in table 21 below (all other HLC Types make up the low probability zone).

Extant field systems: High probability zone				
HLC Type	Sites	PA	PS	Cum Kj
Farmland Prehistoric	67	0.0275	0.2851	0.2710
Coastal Rough Ground	48	0.0151	0.2043	0.4676
Upland Rough Ground	22	0.0284	0.0936	0.5464
Farmland C20	21	0.1076	0.0894	0.5762
Dunes	7	0.0027	0.0298	0.6048
Extant field systems: Medium probability zone				
HLC Type	Sites	PA	PS	Cum Kj
Farmland Medieval	47	0.5215	0.2000	0.4241

Table 21. Predictive model for prehistoric field systems based on the correlation of extant field systems with HLC Types.

The table below summarises the performance of this model.

Probability zone	PA	PS	Kvamme's gain	PS/PA
High	0.18	0.70	0.7419	3.88
Medium	0.52	0.20	-1.6077	0.38
Low	0.30	0.10	-2.0369	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 has 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. The probability map resulting from this model is shown in Fig 16.

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.

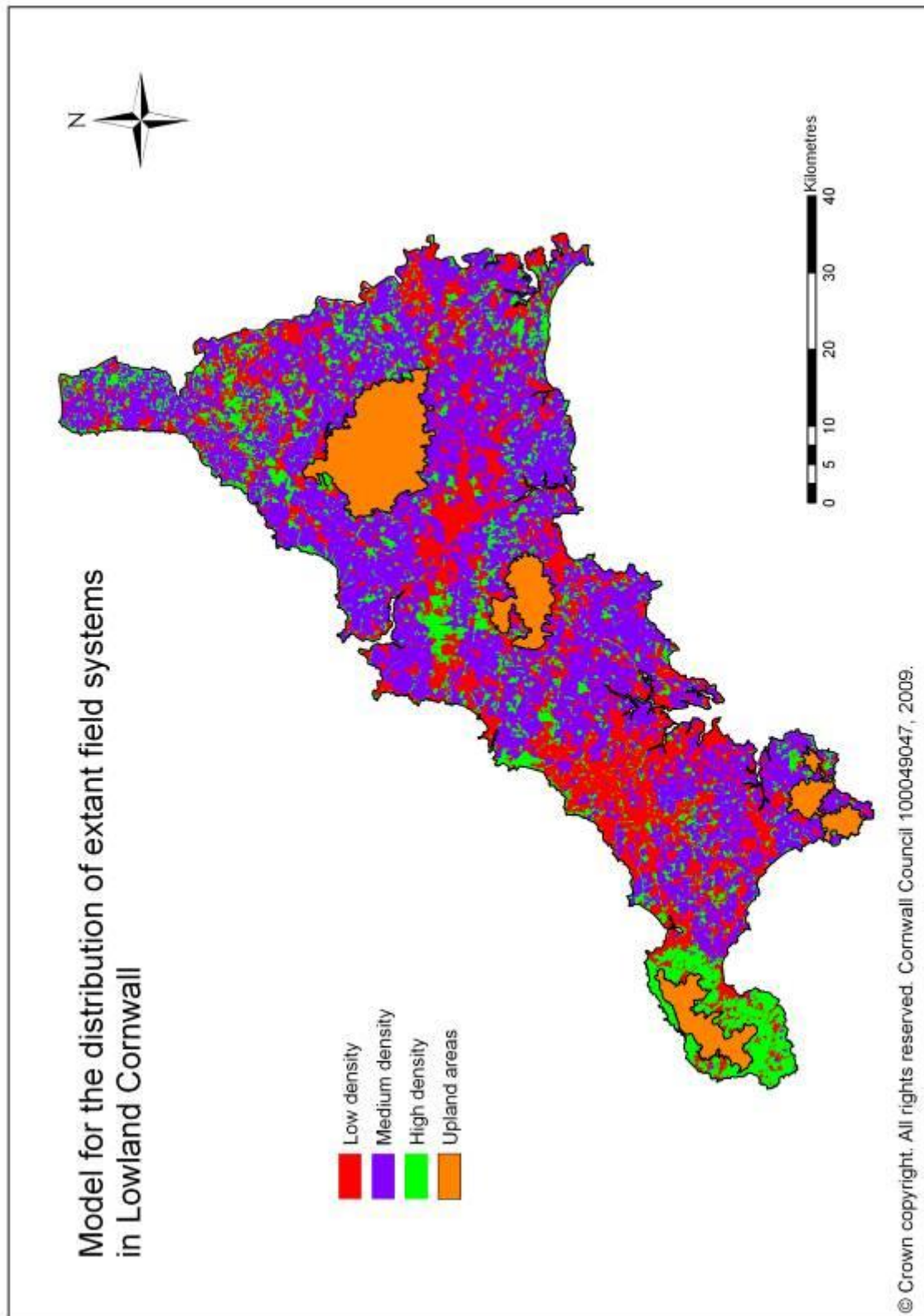


Fig 16. Probability map based on the high level HLC model for extant prehistoric field systems in Lowland Cornwall.

8.1.5 Conclusions

- The high level model for prehistoric field systems based on the 1994 HLC suggests that the HLC Types where field systems are most likely to be found are Farmland Prehistoric, Coastal Rough Ground, Farmland Medieval, Farmland C20 and Upland Rough Ground.
- The model is accurate: 88% of the sites are captured in the high probability zone.
- The model lacks precision: the high probability zone covers 70% of the project area.
- The high probability zone of this model contains roughly equal numbers of cropmark and extant field systems.
- Prehistoric field systems with earthwork or stonework remains surviving are most likely to be found in the HLC Types Farmland Prehistoric, Coastal Rough Ground, Upland Rough Ground, Farmland C20 and Dunes.
- The model for extant field systems is both accurate and precise: 70% of the sites are captured in 18% of the area.
- The model for extant field systems is, however, likely to be retrodictive.
- Cropmark field systems are most likely to be found in the HLC Types Farmland Medieval, Farmland C20 and Farmland Prehistoric.
- The model for cropmark field systems is accurate: 89% of the sites captured in the high probability zone and only 1% in the low probability zone.
- The high probability zone of this model lacks precision and has only a modest Kvamme's gain. Nonetheless it is a more useful predictor than the extant field system model.

8.2 Rounds and enclosures

8.2.1 The distribution of rounds and enclosures in lowland Cornwall

In total 2,365 rounds and enclosures were recorded in the HER at the time the project dataset was created (April 2009). Prior to the analysis and model building process this data was filtered by the removal of more than 400 site records derived from place-name evidence for the reasons outlined above in section 5.1.3.

The filtered dataset used for the analysis contained 1,957 sites. Of these 1,047 are listed in the HER as cropmarks, 437 have above-ground extant remains, 431 are derived from place-name evidence (Cornish place-names containing elements such as *Ker* or *Dyn*), 38 are listed as known sites which have been destroyed, and four are recorded from geophysical surveys.

A significant majority (1,322) are classed as rounds; only 635 as enclosures. The vast majority (1,436) are dated as Iron Age as opposed to Romano-British (9). However this is because of the way the issue of multiple-indexing was resolved (section 5.1.2): many of the IA sites are likely to be listed in the HER as IA/RB. We can say that nine are interpreted as exclusively Romano-British. 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 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 17).

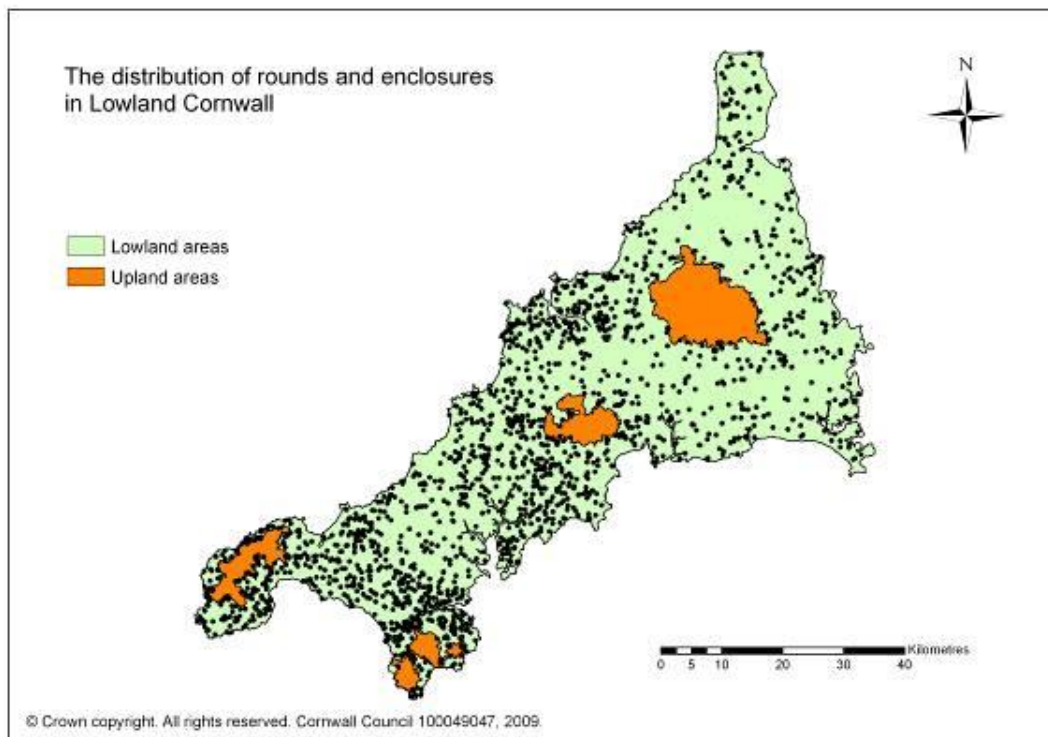


Fig 17. Map showing the distribution of all rounds and enclosures in the Lowland Cornwall project area.

Whilst archaeological factors are probably a factor 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 18). Rounds and enclosures identified

from Cornish place-name evidence are largely absent from east Cornwall (Fig 19) where English place-names predominate (Preston-Jones and Rose 1986, 141-143). By contrast the distribution of extant rounds and enclosures (those with earthwork remains) is more even throughout the project area (Fig 20).

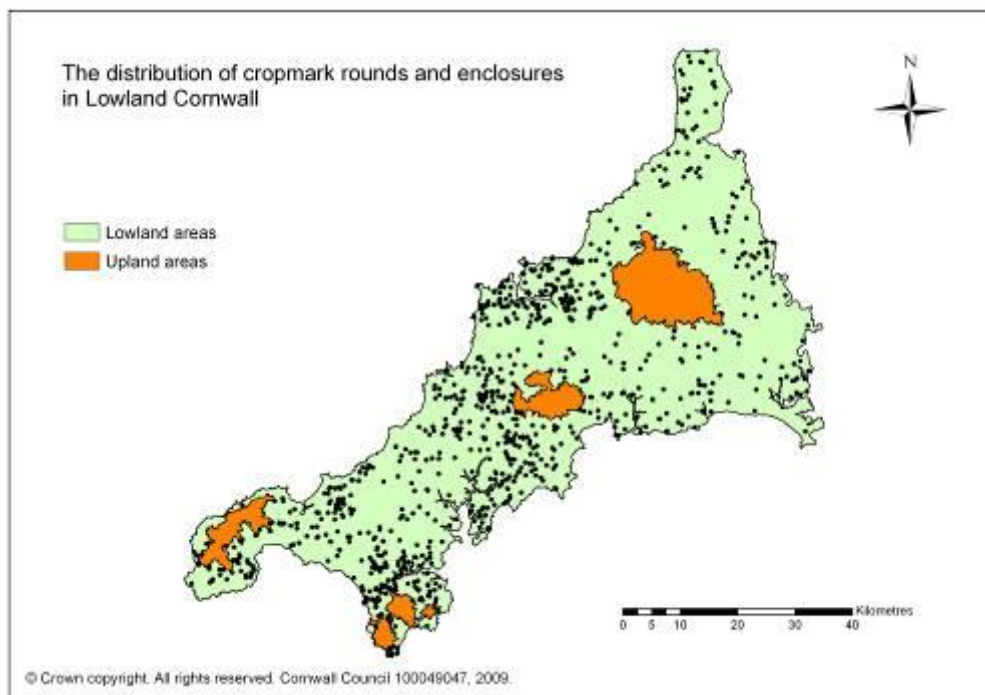


Fig 18. Map showing the distribution of cropmark rounds and enclosures in the Lowland Cornwall project area.

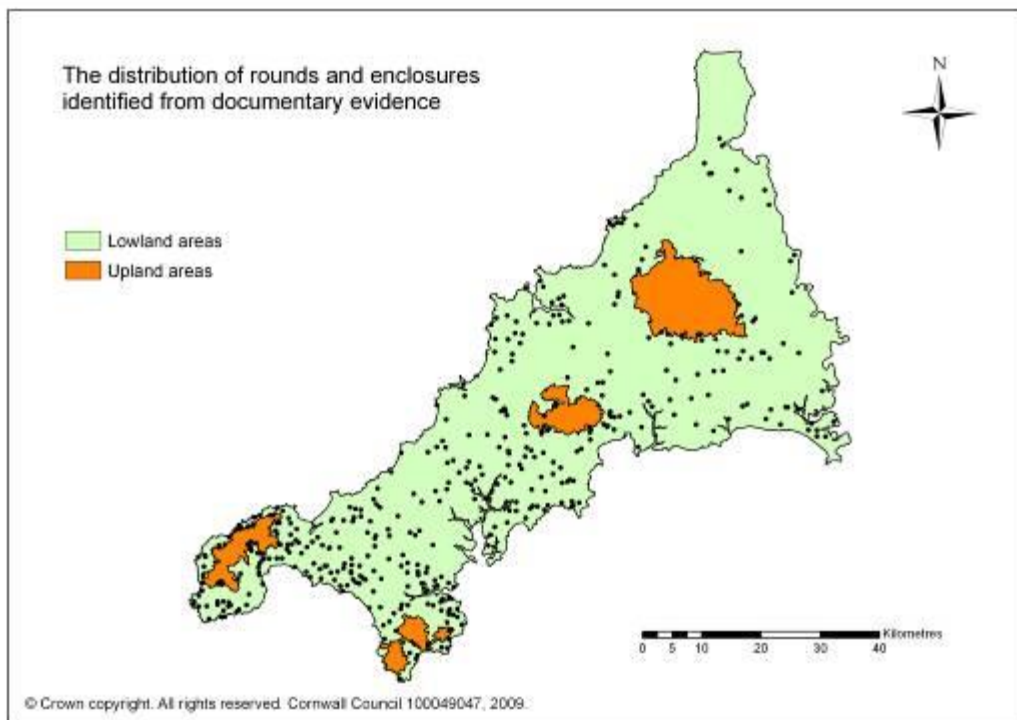


Fig 19. Map showing the distribution of rounds and enclosures identified from documentary evidence in the Lowland Cornwall project area.

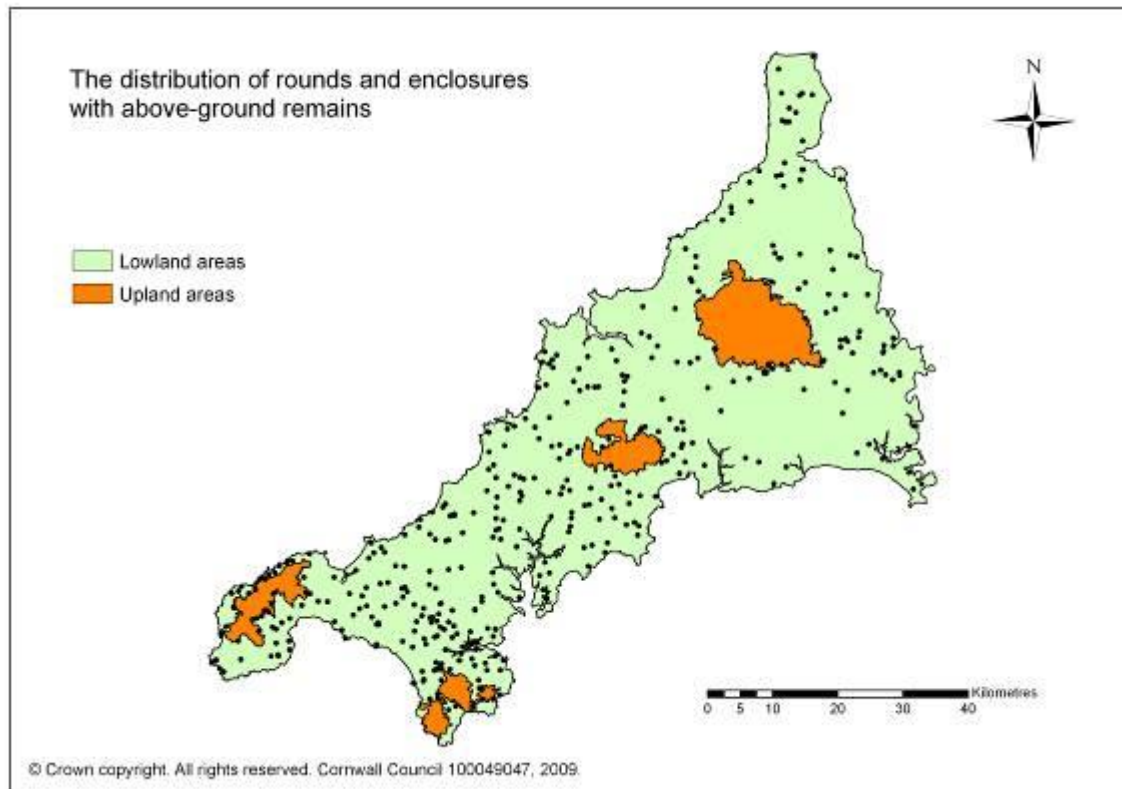


Fig 20. Map showing the distribution of rounds and enclosures with surviving above-ground remains.

8.2.2 High level model for all recorded rounds and enclosures

The high level model based on the distribution of rounds and enclosures correlated with HLC Types is summarised in the tables below.

Rounds and enclosures. High probability zone				
HLC Type	Sites	PA	PS	Cum Kj
Farmland Medieval	1175	0.5215	0.6004	0.2176
Farmland Prehistoric	148	0.0275	0.0756	0.2930
Farmland C20	228	0.1076	0.1165	0.3282
Total	1551	0.6566	0.7925	
Rounds and enclosures. Medium probability zone				
HLC Type	Sites	PA	PS	Cum Kj
Farmland Post medieval	243	0.1599	0.1242	0.3030
Coastal Rough Ground	25	0.0151	0.0128	0.3016
Dunes	5	0.0027	0.0026	0.2480
Recreational	11	0.0062	0.0056	0.2479
Rough Ground/Industrial	2	0.0012	0.0010	0.1791
Total	286	0.1851	0.1462	

Table 22. Predictive model for rounds and enclosures based on the correlation of extant field systems with HLC Types.

All other HLC Types make up the low probability zone. The performance of the model is summarised below.

Probability zone	PA	PS	Kvamme's gain	PS/PA
High	0.66	0.79	0.1715	1.21
Medium	0.19	0.15	-0.266	0.79
Low	0.16	0.06	-1.5798	0.39

In the model the important HLC Types are all field Types (more than 90% of the sites are located in these Types). Of these, Farmland Post Medieval is ranked lowest, despite containing 243 sites as opposed to 148 in Farmland Prehistoric and 228 in Farmland C20. This is because Farmland Post Medieval covers a larger area than Farmland C20 and a far larger area than Farmland Prehistoric. The low density zone is largely made up of woodland Types and others such as Military and Ornamental, that have been 'imposed' on land which would formerly have been a different HLC Type.

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 66% of the project area (Fig 21). 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 very clearly illustrated by the probability map derived from it (Fig 21). 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 comprising the St Agnes, Gwennap, Wendron and Camborne and Redruth mining districts. This area stretches from Portreath and St Agnes in the north to Camborne in the west and through Chacewater and Mabe in the south.

Other notable areas forming the medium or low probability zones are St Breock Downs, Bodmin and the Fowey Valley in central Cornwall; Callington, Calstock and St Ive in the east and parts of the Culm measures in the north east, particularly around North Petherwin, Werrington, Warbstow and Jacobstow.

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 appears to be broadly correct – these are the two highest ranked HLC Types in the model. It is possible that the lack of precision inherent in the model may be rectified by refinement of the existing HLC, especially if this involves the subdivision of Farmland Medieval into a number of less extensive sub-types. Assuming that some of the sub-types will contain significantly more or less enclosures than others, the size of the high probability zone will effectively be reduced and the precision (and the gain measures) of the model will thereby be increased. It is also likely that defining the previous HLC of Farmland C20 might strengthen the model because the high ranking of Farmland C20 probably reflects the presence of rounds and 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.

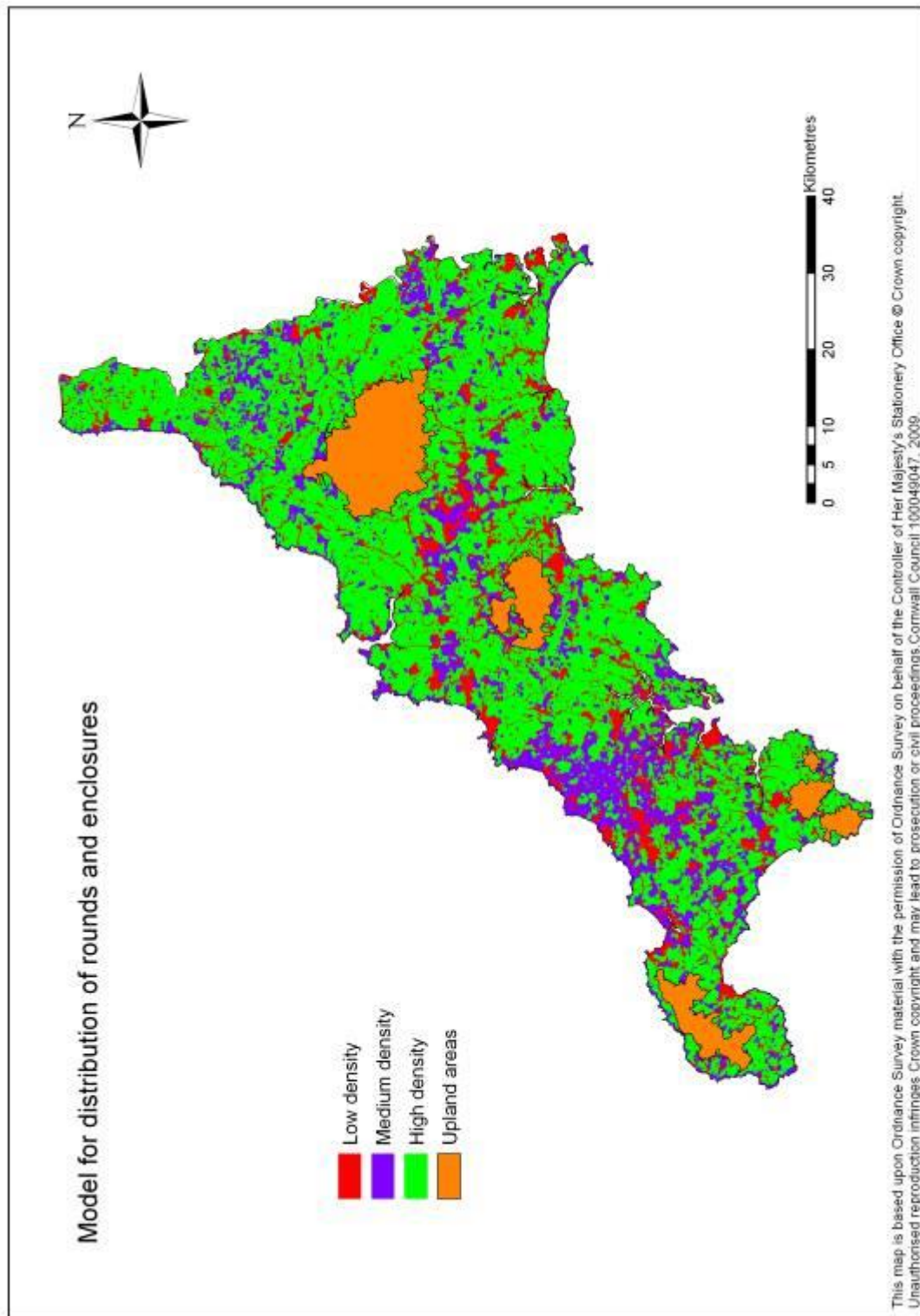


Fig 21. Probability map based on the high level HLC model for all recorded rounds and enclosures in Lowland Cornwall.

It is of interest to analyse the nature of the evidence for the sites, as expressed in the HER field 'form'. The proportion of cropmark enclosures, extant enclosures and documentary enclosures found in the high and medium probability zones is very similar

to the proportion of these forms making up the total dataset (i.e. 54% of the total number of enclosures are cropmarks and 54% of enclosures captured in the high probability zone are cropmarks). However, the make-up of the corpus of enclosures in the low probability zone differs significantly from that of the overall dataset. Only 18% of enclosures in the low probability zone are cropmarks (as opposed to 54% of the overall dataset), and the percentages of extant and documentary enclosures in the low probability zone are considerably higher than in the overall dataset.

There are five times as many cropmark rounds and enclosures captured in the high probability zone as in the other two zones combined. There are three times as many extant rounds and enclosures in the high probability zone as in the other two zones and four times as many documentary references to rounds and enclosures in the high probability zone than in the other two zones combined. It may be that geology and soil types skew the distribution of rounds and enclosures in favour of those types conducive to cropmark production, and the extent to which this is the case is discussed in detail in volume 2 of this report (Young 2012). However, the fact that the proportions of cropmark, extant and documentary enclosures in the high probability zone are virtually identical to the proportion of these forms in the overall dataset (54%, 22% and 22% respectively) suggests that if there is any bias, it is limited. In fact, if the cropmark enclosures are removed from the dataset, the high probability zone would remain the zone of high probability, although the make-up of the low and medium probability zones may change.

Analysis of the rounds and enclosures by form is shown in table 23 below. In this table the percentage figures refer to the proportion of forms of remains of enclosures within each probability zone. For example, 18% of enclosures in the low probability zone are cropmarks and 21% of enclosures in the high probability zone are extant.

Rounds and enclosures high level model				
Form	Low probability zone	Medium probability zone	High probability zone	Total
Cropmark	22 (18%)	154 (54%)	871 (56%)	1047 (54%)
Extant	47 (39%)	68 (24%)	322 (21%)	437 (22%)
Documentary	39 (33%)	51 (18%)	340 (22%)	430 (22%)
Site of	11 (9%)	11 (4%)	16 (1%)	38 (2%)
Geophysical	1 (1%)	1	2	4
Artefact	0	1	0	1
Total	120	286	1551	1957

Table 23. Form of remains of rounds and enclosures in each of the three zones of the model.

On the other hand, models created for cropmark enclosures and extant enclosures display some differences. These are outlined below.

8.2.3 High level model for cropmark rounds and enclosures

The model based only on cropmark rounds and enclosures is slightly at variance with the model for all rounds and enclosures in that the high probability zone is made up only of Farmland Medieval and Farmland C20 – Farmland Prehistoric drops into the medium probability zone and is ranked lower than Farmland Post medieval. HLC Types such as Recreational and Coastal Rough Ground, which are in the zone of medium probability in the model for all enclosures, drop into the low probability zone in this model (table 24).

Cropmark rounds and enclosures. High probability zone					
HLC Type	Sites	PA	PS	Cum Kj	Rel gain
Farmland Medieval	694	0.5215	0.6628	0.3060	0.1413
Farmland C20	128	0.1076	0.1223	0.3499	0.1560
Total	822	0.6291	0.7851		
Cropmark rounds and enclosures. Medium probability zone					
HLC Type	Sites	PA	PS	Cum Kj	Rel gain
Farmland Post medieval	149	0.1599	0.1423	0.3582	0.1384
Farmland Prehistoric	49	0.0275	0.0468	0.3919	0.1577
Total	198	0.1874	0.1891		

Table 24. The high and medium probability zones of the model for cropmark rounds and enclosures.

One problem encountered when building this model was that the cumulative Kj values continued to increase to a maximum of 0.3919 (see table 24) before falling back. Using the Kj measures alone to define the cut off point for the high probability zone would have resulted in this zone capturing more than 97% but covering almost 82% of the project area. In this case Relative Gain measures (PS-PA, see section 7.2.1) were also considered when defining the cut-off point. Relative Gain values rise to 0.1560 and then fall to 0.1384 (table 24) indicating that only the HLC Types Farmland Medieval and Farmland C20 form the high probability zone. The performance of the model is summarised below.

Probability zone	PA	PS	Kvamme's gain	PS/PA
High	0.63	0.79	0.1987	1.25
Medium	0.19	0.19	0.009	1
Low	0.18	0.03	-6.1143	0.16

This model has the same level of accuracy as the model for all rounds and enclosures, with 79% captured in the high probability zone. It is slightly more precise in that the high probability zone covers 63% of Lowland Cornwall (as opposed to 66% in the model for all enclosures). The chances of encountering an enclosure in the high probability zone are eight times greater than in the low probability zone.

8.2.4 High level model for extant rounds and enclosures

Although both HLC Types Farmland Medieval and Farmland C20 (which make up the high probability zone in the cropmark model) are contained within the high probability zone for the extant enclosures model, this zone includes other Types, such as Upland Rough Ground, which forms part of the low probability zone in the models for all enclosures and cropmark enclosures.

Extant rounds and enclosures. High probability zone				
HLC Type	Sites	PA	PS	Cum Kj
Farmland Medieval	239	0.5215	0.5469	0.1178
Farmland Prehistoric	33	0.0275	0.0755	0.2137
Farmland C20	50	0.1076	0.1144	0.2432
Coastal Rough Ground	15	0.0151	0.0343	0.2769
Upland Rough Ground	17	0.0284	0.0389	0.2985
Total	354	0.7001	0.81	

Extant rounds and enclosures. Medium probability zone				
HLC Type	Sites	PA	PS	Cum Kj
Plantation and Scrub	12	0.0362	0.0275	0.2913
Farmland Post medieval	44	0.1599	0.1007	0.1986
Dunes	4	0.0027	0.0026	0.2144
Ancient Woodland	6	0.0223	0.0137	0.1959
Recreational	3	0.0062	0.0069	0.1981
Rough Ground/Industrial	2	0.0012	0.0046	0.2068
Total	71	0.2285	0.156	

Table 25. The high and medium probability zones of the model for extant rounds and enclosures.

The zone of medium probability contains two HC Types which are firmly in the low probability zone of the model for all enclosures: Plantation and Scrub (in fact there is a case, looking at the cumulative Kj scores, to include this Type in the high probability zone) and Ancient Woodland. The performance of the model is summarised in the table below.

Probability zone	PA	PS	Kvamme's gain	PS/PA
High	0.70	0.81	0.1358	1.16
Medium	0.23	0.16	-0.4063	0.70
Low	0.07	0.03	-1.6016	0.43

Of the three models for rounds and enclosures presented here, that for extant rounds is weakest in terms of performance, typified by its low Kvamme's gain. The main difficulty is the very small low probability zone, covering only 7% of lowland Cornwall. Another significant weakness is the performance of the highest ranked HLC Type, Farmland Medieval. This Type covers 52% of the area but only contains 54.7% of the enclosures. To all intents and purposes this represents a by chance distribution with its PS value being very similar to its PA value.

8.2.5 Conclusions

- The high level model for rounds and enclosures based on the 1994 HLC suggests that the HLC Types where enclosures are most likely to be found are, in order of importance, Farmland Medieval, Farmland Prehistoric and Farmland C20.
- The model is accurate: 79% of the sites are captured in the high probability zone.
- The model lacks precision: the high probability zone covers 66% of the project area.
- The high probability zone of this model contains many more cropmark sites than extant enclosures or those recorded from documentary references.
- The fact that three times more extant enclosures are found within the high probability zone of the model than in the two other zones combined suggests that any bias towards cropmark-rich areas in the model is limited.
- Cropmark enclosures are most likely to be found in the HLC Types Farmland Medieval and Farmland C20.

- Rounds and enclosures with earthwork remains surviving are most likely to be found in the HLC Types Farmland Medieval, Farmland Prehistoric, Farmland C20, Coastal Rough Ground and Upland Rough Ground.
- The model for cropmark enclosures is slightly more precise than that for all recorded rounds and enclosures.
- The model for extant rounds and enclosures is weaker than that for all rounds and enclosures and the highest ranked HLC Type displays an essentially 'by chance' distribution.
- Overall the model broadly supports the assertion that the HLC Zone Anciently Enclosed Land represents the zone of prehistoric and Romano-British settlement.

8.3 Open settlements

Open settlements were identified by extracting from the HER all sites interpreted as hut circle or round house. The dataset was filtered as described in section 5.1.3 above. The filtered dataset contains 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 22).

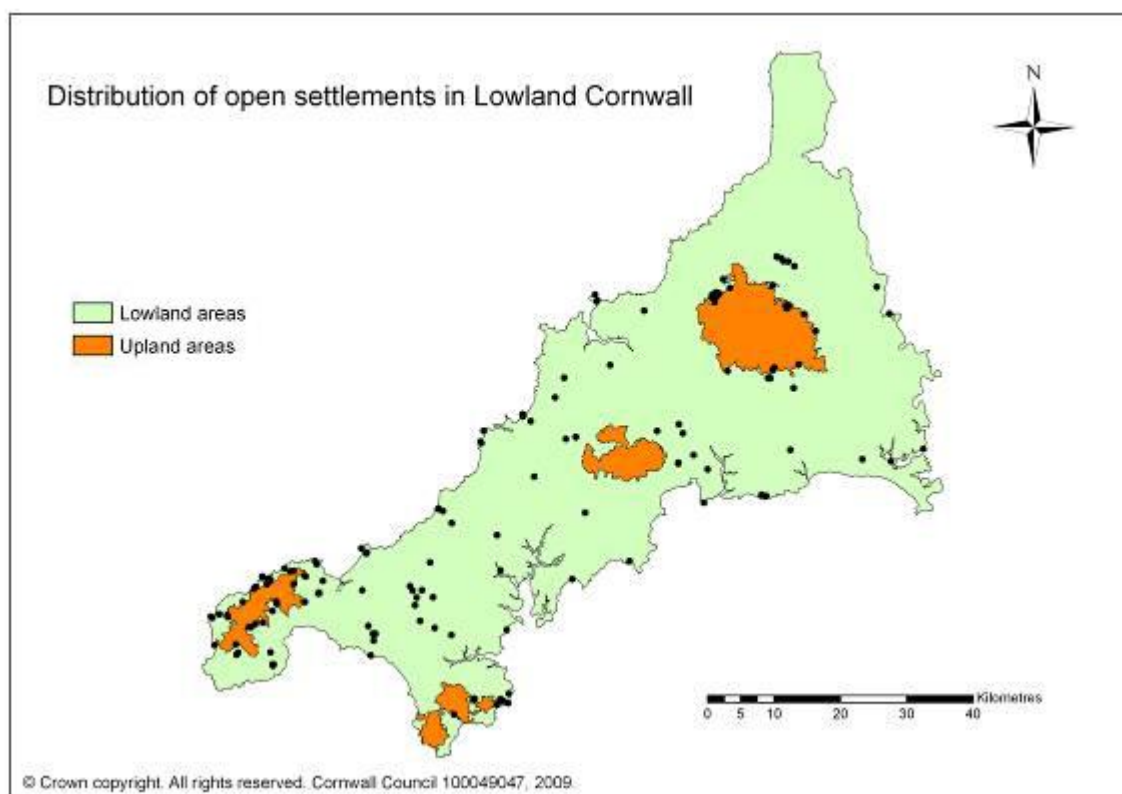


Fig 22. Map showing the distribution of all open settlements in the Lowland Cornwall project area.

Plainly the settlement pattern is heavily influenced by the form of survival of the sites: although round houses do 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). In Lowland Cornwall only 24 records for cropmark

round houses are listed in the HER (Fig 23). Conversely 70% of the sites have extant remains (Fig 24), and where these occur they are located within or on the fringes of HLC Types which are upland in character, such as Upland Rough Ground and Coastal Rough Ground.

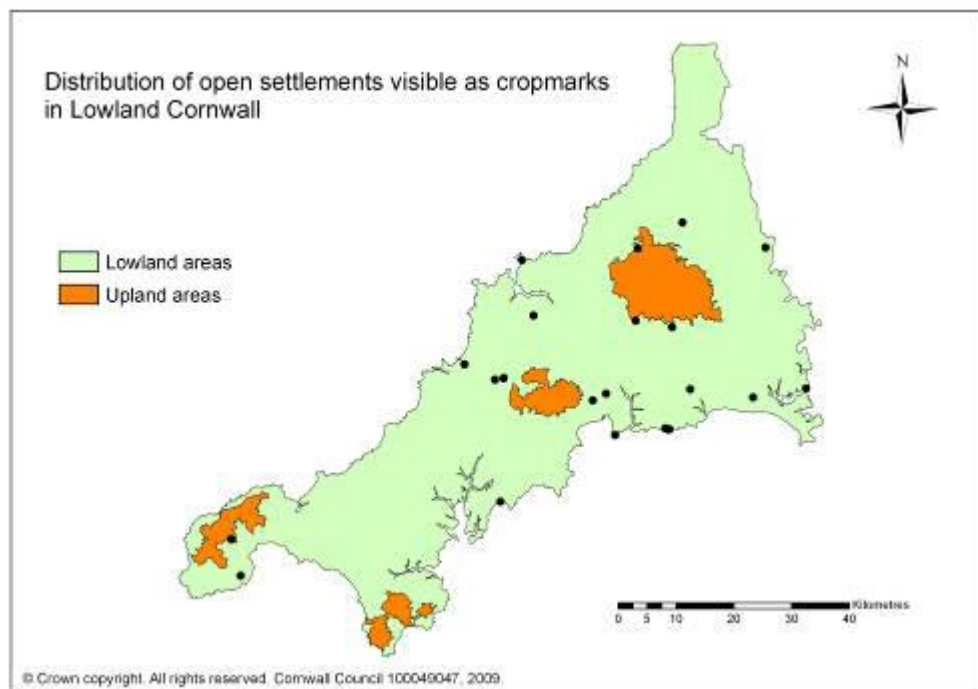


Fig 23. Map showing the distribution of open settlements visible as cropmarks in the Lowland Cornwall project area.

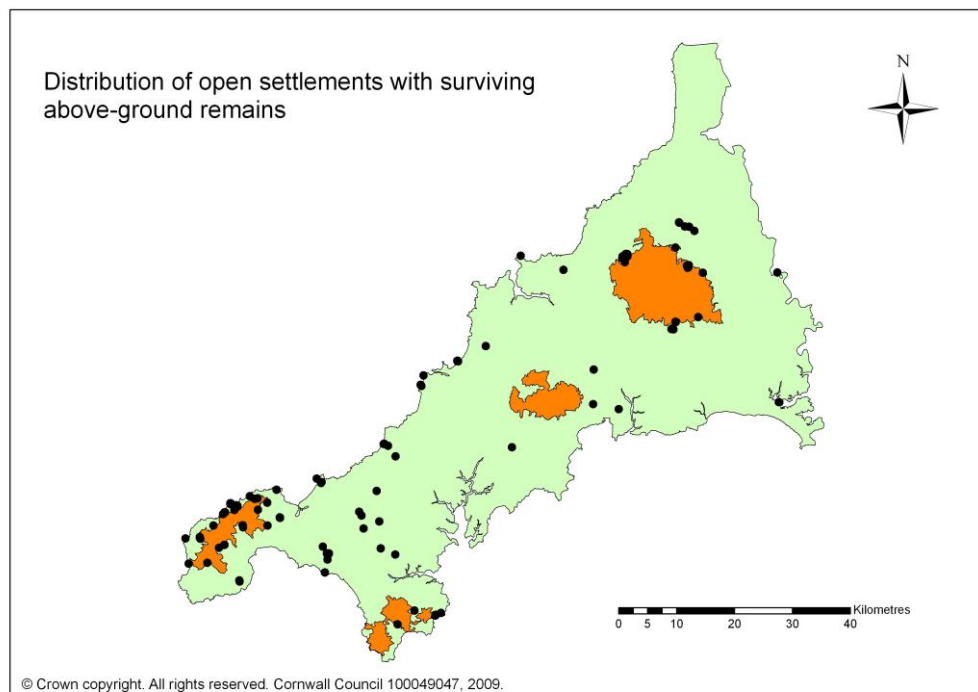


Fig 24. Map showing the distribution of open settlements with surviving above-ground remains.

The high level model based on the distribution of open settlements correlated with HLC Types is summarised table 26 below.

Open settlements: High probability zone				
HLC Type	Sites	PA	PS	Cum Kj
Coastal Rough Ground	58	0.0151	0.2014	0.1937
Upland Rough Ground	34	0.0284	0.1181	0.2969
Farmland Prehistoric	33	0.0275	0.1146	0.3970
Farmland Post Medieval	40	0.1599	0.1389	0.4427
Farmland C20	27	0.1076	0.0938	0.4678
Settlement C20	14	0.0309	0.0486	0.4974
Military	8	0.0055	0.0278	0.5231
Dunes	7	0.0027	0.0243	0.5469
Plantation and Scrub	7	0.0362	0.0243	0.5470
Total	228	0.4138	0.7918	
Open settlements: Medium probability zone				
HLC Type	Sites	PA	PS	Cum Kj
Farmland Medieval	55	0.5215	0.1910	0.2157
Settlement older core	1	0.0052	0.0035	0.2121
Water: Natural	1	0.0059	0.0035	0.2068
Recreational	1	0.0062	0.0035	0.2005
Total	58	0.5388	0.2015	

Table 26. The high and medium probability zones of the model for open settlements.

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. The performance of the model is summarised in the table below.

Probability zone	PA	PS	Kvamme's gain	PS/PA
High	0.41	0.79	0.4774	1.91
Medium	0.54	0.20	-1.6757	0.37
Low	0.05	0.007	-5.8268	0.15

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.

The ratio of Indicative Values (PS/PA) indicates that the chance of encountering a site in the high probability zone is five times higher than in the medium probability zone

and 12.7 times higher than in the low probability zone. The likelihood of encountering a site in the medium probability zone is 2.5 times higher than in the low probability zone.

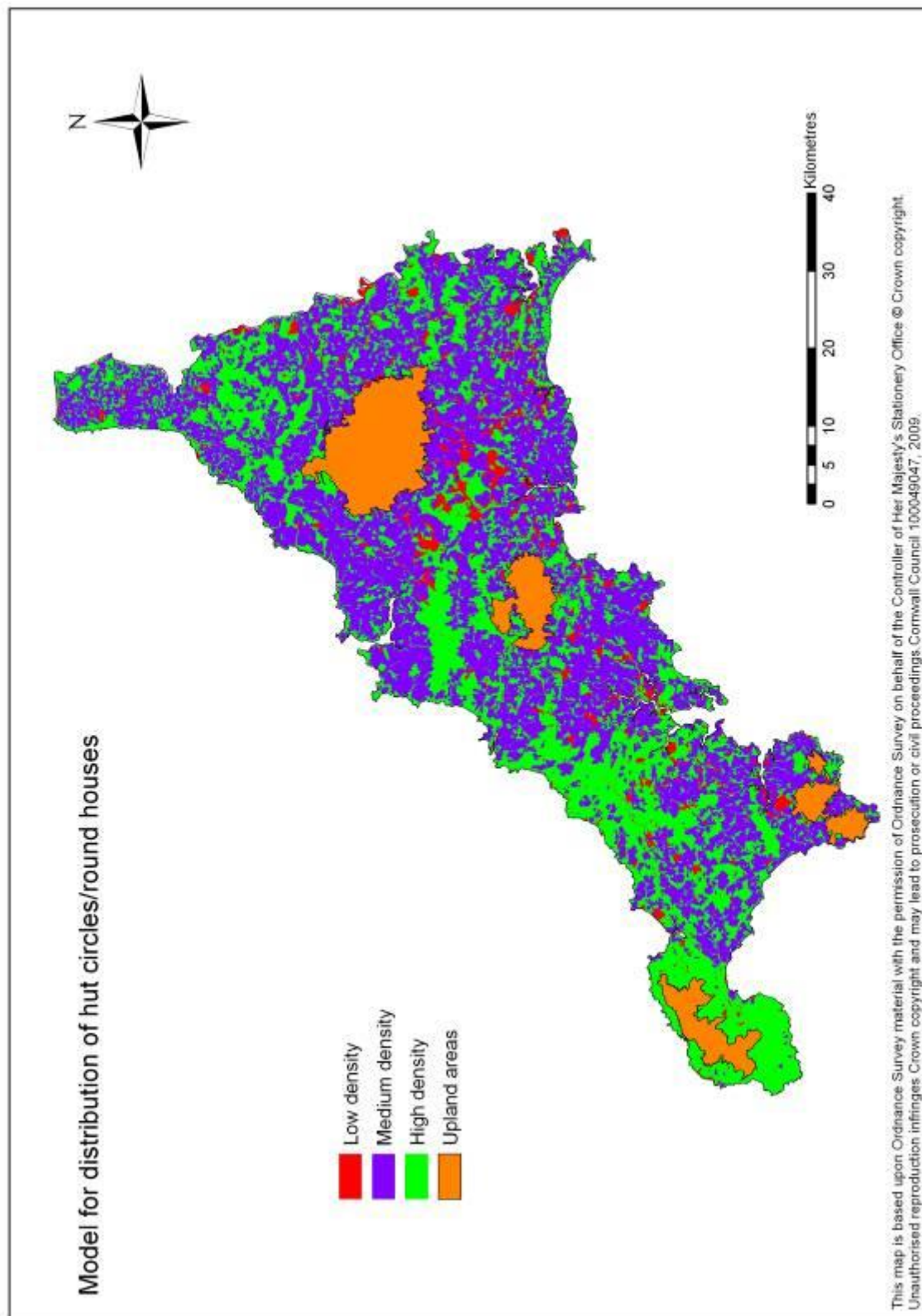


Fig 25. Probability map based on the high level HLC model for prehistoric open settlements in Lowland Cornwall.

This analysis indicates that the distribution of open settlements is probably better presented as a two-zone model - with the high probability zone as summarised above, and a low probability zone comprising the medium and low probability zones. The performance of this model is shown in the table below.

Probability zone	PA	PS	Kvamme's gain	PS/PA
High	0.41	0.79	0.4774	1.91
Low	0.59	0.21	-1.8156	0.36

A probability map based on the three-zone model is shown in Fig 25. As noted above the medium and low probability zones in the map are, to all intents and purposes, interchangeable.

The probability map is virtually a mirror image of that for rounds and enclosures (section 8.2). The only similarity between the two is the ranking of Farmland Prehistoric (which is confined to West Penwith) in the high probability zone of both models. 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 (potentially large) number of open settlements in parts of Lowland Cornwall, particularly 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 round houses, and by the general lack of evidence for round houses inside rounds and enclosures recorded from aerial photographs during Cornwall's NMP (the rate of visibility on aerial photos of round houses within enclosures has not been quantified but is not great). And it is worth noting that 50% of cropmark round houses are located in the medium probability zone (i.e. in areas of Farmland Medieval).

The likelihood that plough-levelled open settlements in lowland areas do not form consistently visible cropmarks is underlined by the fact that only 8% of the open settlements in the project dataset were identified from cropmark evidence. A full breakdown of the settlements according to their form of remains is set out in table 27 below.

Zone	Cropmark	Extant	Documentary	Site of	Artefact ¹	Total
High	11 (46%)	169 (84%)	15 (75%)	32 (82%)	1	228
Medium	12 (50%)	32 (15.5%)	5 (25%)	7 (18%)	2	58
Low	1 (4%)	1 (0.5%)	0	0	0	2
Total	24	202	20	39	3	288
Percent of total	8%	70%	7%	14%	1%	

Table 27. Breakdown of HER records for hut circles and round houses based on form of remains.

¹ Sites whose form is listed as artefact: where finds have been made which support documentary references to hut circles, either from field-name evidence or antiquarian reports.

8.3.1 Conclusions

- The high level model for open settlements based on the 1994 HLC suggests that the HLC Types where enclosures are most likely to be found are, in order of importance; Coastal Rough Ground, Upland Rough Ground, Farmland Prehistoric, Farmland Post Medieval and Farmland C20. Small numbers of settlements are located in HLC Types Settlement C20, Military, Dunes and Plantation and Scrub, but, nonetheless, these Types are ranked higher in the model than Farmland Medieval.
- The model is accurate: 79% of the sites are captured in the high probability zone.
- The model is reasonably precise: the high probability zone covers 41% of the project area.
- The vast majority of round houses in the high probability zone have above ground extant remains and only 8% of round houses in the dataset are recorded as cropmarks.
- The fact that 70% of roundhouses in the dataset are recorded as extant suggests that the distribution pattern of open settlements is heavily biased towards those areas where extant remains are most likely to survive – i.e. in Rough Ground and in parts of Farmland Post Medieval.
- Cropmark round houses are most likely to be found in the HLC Types Farmland Medieval and Farmland C20.
- Although there are substantial numbers of round houses in the HLC Type Farmland Prehistoric, very few are recorded from Farmland Medieval. Overall, therefore, the model rejects the assertion that the HLC Zone Anciently Enclosed Land represents the zone of prehistoric and Romano-British settlement with regard to open settlements. However, there is likely to be an unquantified number of as yet undiscovered settlements in areas of Farmland Medieval and this model can be regarded with some scepticism.

8.4 Bronze Age barrows

In total 2,120 Bronze Age barrows are recorded in the HER. Their distribution is marked by dense concentrations in West Penwith, the Lizard Peninsula, the Roseland Peninsula and the area between Truro and St Agnes, as well as by a number of significant clusters, including linear groupings at St Breock Downs, Hingston Down and around Week St Mary (Fig 26).

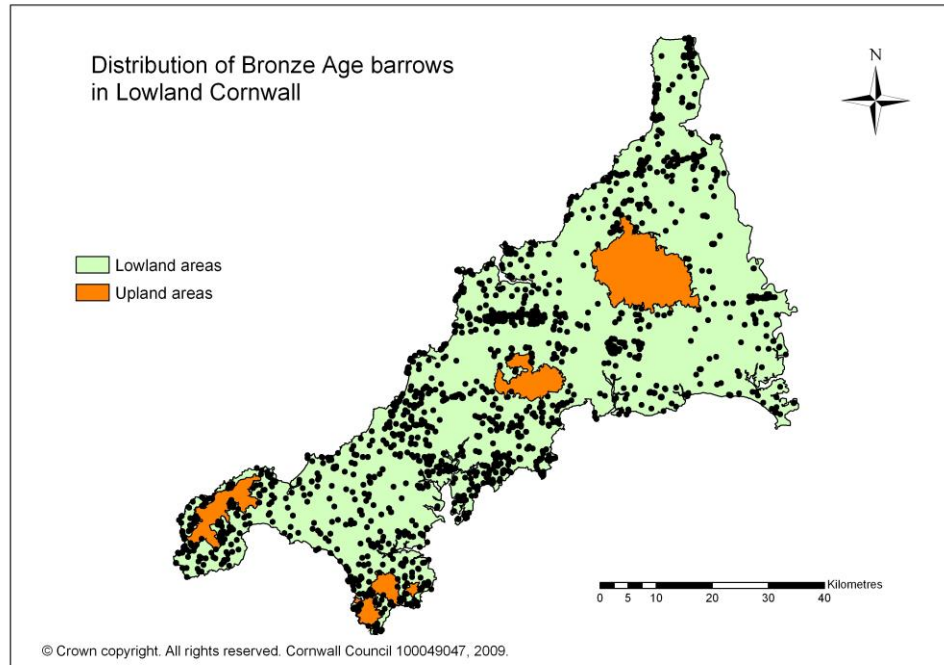


Fig 26. Map showing the distribution of all Bronze Age barrows in the Lowland Cornwall project area.

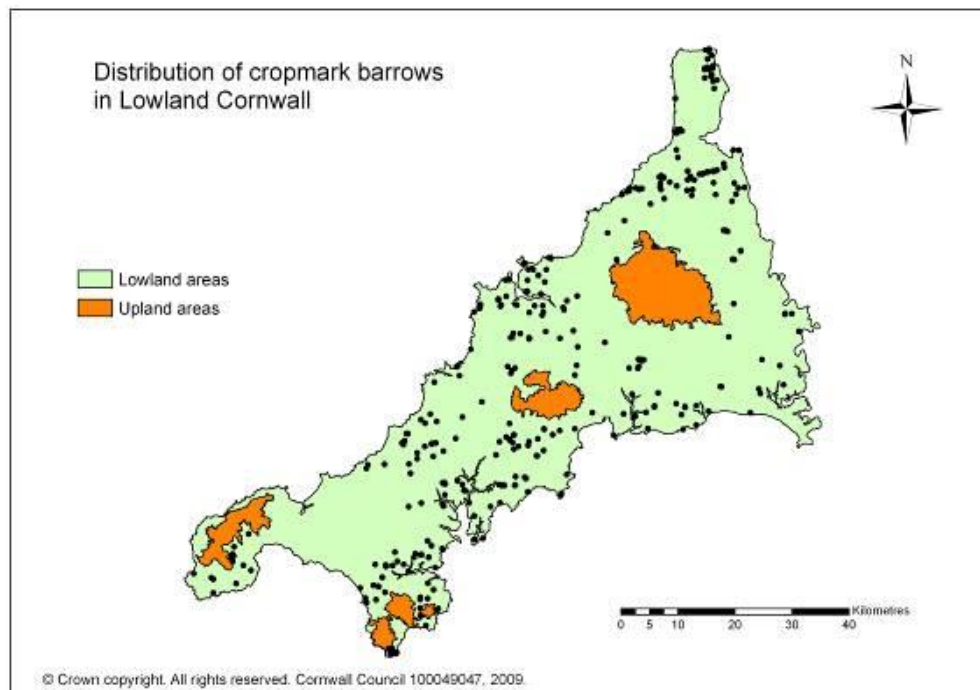


Fig 27. Map showing the distribution of Bronze Age barrows visible as cropmarks in the Lowland Cornwall project area.

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 area between Truro and St Agnes, in West Penwith and on the Lizard peninsula. Of the linear groupings, those on St Breock Downs and Hingston Down are predominantly earthworks, whilst the Week St Mary group contains a mixture of cropmark and extant sites (Figs 27 and 28).

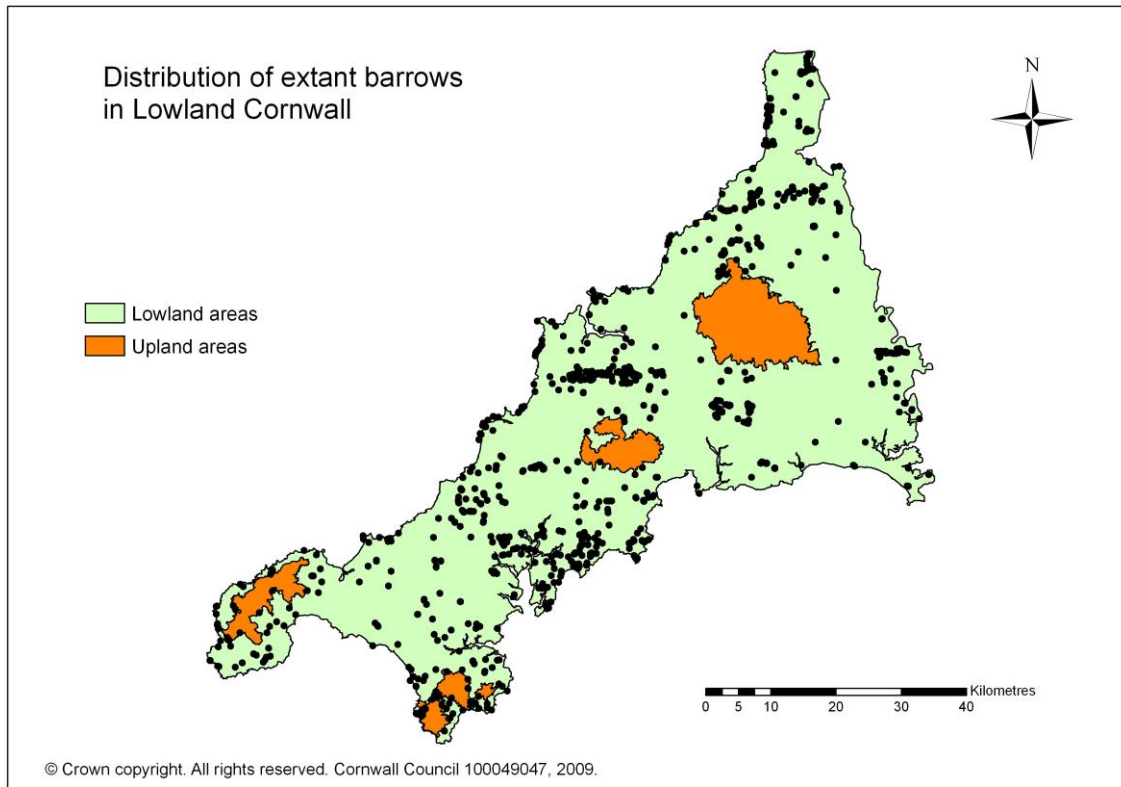


Fig 28. Map showing the distribution of Bronze Age barrows with surviving above-ground remains in the Lowland Cornwall project area.

The high level model based on the distribution of barrows correlated with HLC Types is summarised in table 28 below.

Bronze Age barrows: High probability zone				
HLC Type	Sites	PA	PS	Cum Kj
Farmland Post medieval	633	0.1599	0.2986	0.2035
Farmland C20	324	0.1076	0.1528	0.2881
Coastal Rough Ground	114	0.0151	0.0538	0.3353
Upland Rough Ground	85	0.0284	0.0401	0.3574
Farmland Prehistoric	83	0.0275	0.0392	0.3792
Settlement C20	59	0.0309	0.0278	0.3857
Total	1298	0.3694	0.6123	

Bronze Age barrows: Medium probability zone				
HLC Type	Sites	PA	PS	Cum Kj
Farmland Medieval	684	0.5215	0.3226	0.2029
Rough Ground/Industrial	19	0.0012	0.0090	0.2212
Recreational	22	0.0062	0.0104	0.2312
Total	725	0.5289	0.342	

Table 28. The high and medium probability zones of the high level model for Bronze Age barrows.

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 performance of the model is summarised in the table below.

Probability zone	PA	PS	Kvamme's gain	PS/PA
High	0.37	0.61	0.3968	1.66
Medium	0.53	0.34	-0.5466	0.65
Low	0.10	0.05	-1.2238	0.45

The high probability zone has a reasonable Kvamme's gain measure and is both accurate and precise, with 61% of sites captured in 37% of the project area. 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 probability 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 probability 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 29). 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 rounds and enclosures in that Farmland Post Medieval and the Rough Ground Types form the zone of high probability and Farmland Medieval, whilst containing more sites than any other HLC Type, 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. From table 29 below it can be seen that more than half the barrows have above-ground extant remains, whilst only 19% are recorded as cropmarks. 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 extant barrows are recorded as extant. By contrast 47% of cropmark barrows are located in this zone.

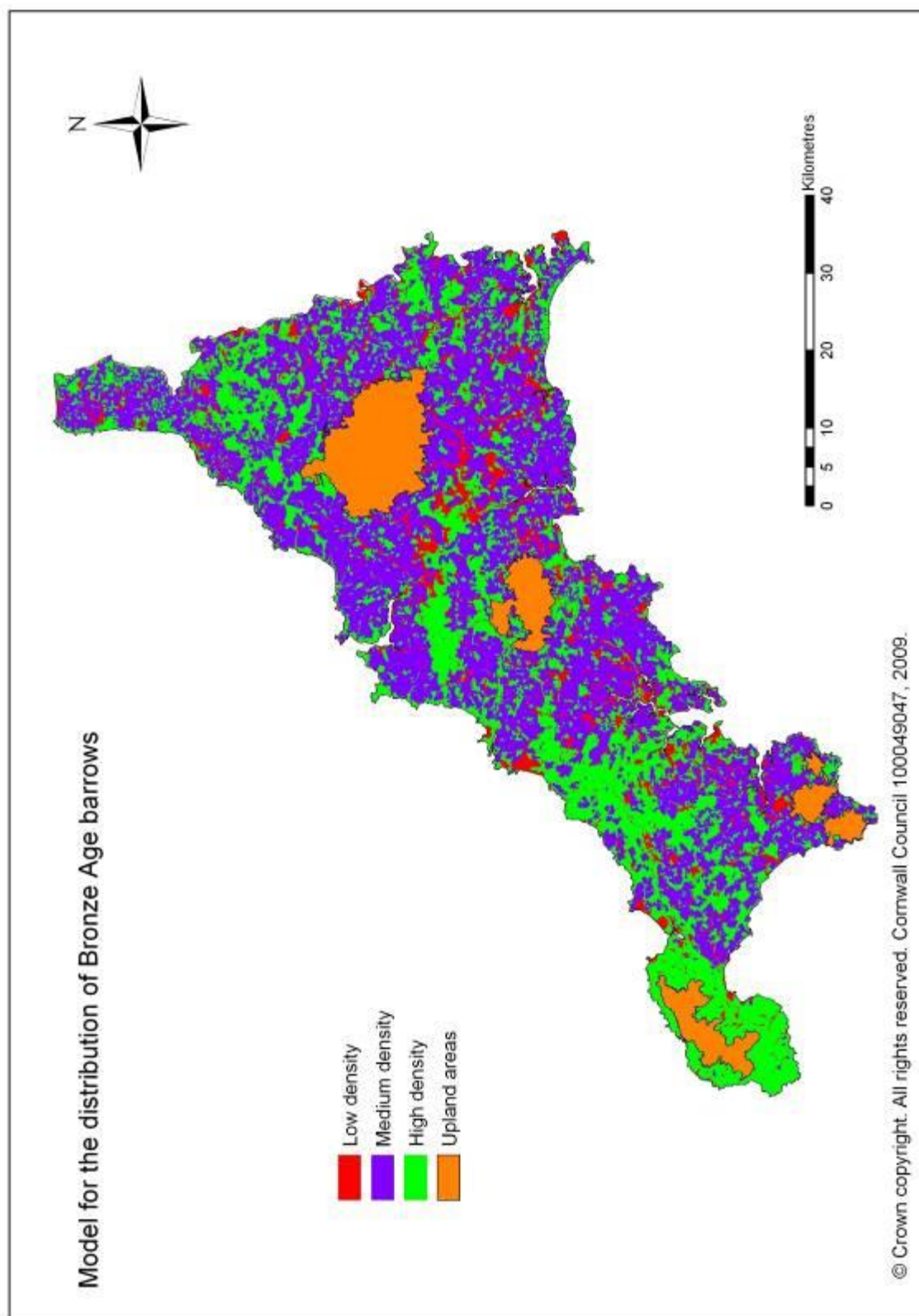


Fig 29. Probability map based on the high level HLC model for Bronze Age barrows in Lowland Cornwall.

Zone	Cropmark	Extant	Documentary	Site of	Total	Percent
High	200 (50%)	706 (65%)	294 (61%)	98 (66%)		61%
Medium	189 (47%)	340 (31%)	166 (35%)	30 (20%)		34%
Low	9 (2%)	47 (4%)	21 (4%)	20 (14%)		5%
Total	398	1093	481	148		
Percent	19%	51%	23%	7%		

Table 29. Breakdown of HER records for Bronze Age barrows based on form of survival.

From the figures in this table it is clear that a significant majority of extant barrows are captured in the high probability zone (65%) and the same is true of barrows recorded from documentary evidence (61%) and those which have been destroyed since they were recorded (66%). By contrast the capture of cropmark barrows is fairly evenly divided between the high and medium probability zones (50 and 47% respectively).

8.4.1 High level model for cropmark barrows

A model based on only the cropmark barrows ranks the HLC Type Farmland Medieval third in importance and places it in the high probability zone.

Cropmark barrows: High probability zone				
HLC Type	Sites	PA	PS	Cum Kj
Farmland Post medieval	109	0.1599	0.2739	0.1766
Farmland C20	68	0.1076	0.1709	0.2807
Farmland Medieval	188	0.5215	0.4724	0.3427
Coastal Rough Ground	9	0.0151	0.0226	0.3569
Total	374	0.8041	0.9398	
Cropmark barrows: Medium probability zone				
HLC Type	Sites	PA	PS	Cum Kj
Farmland Prehistoric	9	0.0275	0.0226	0.3546
Ornamental	6	0.0137	0.0151	0.3592
Upland Rough Ground	3	0.0284	0.0075	0.3309
Plantation and Scrub	3	0.0362	0.0075	0.2863
Total	21	0.1058	0.0527	

Table 30. High and medium probability zones of the high level model for cropmark barrows.

This model, however, does not perform well, as shown in the table below.

Probability zone	PA	PS	Kvamme's gain	PS/PA
High	0.8042	0.9397	0.1442	1.17
Medium	0.1057	0.0528	-1.0038	0.50
Low	0.0901	0.0075	-10.9538	0.08

The weakness of this model is the very large area covered by the high probability zone (80% of the project area). Although some 94% of the barrows are captured in this zone the model is suggesting that there is a high likelihood of encountering a cropmark barrow almost anywhere in Lowland Cornwall.

There is doubtless considerable potential for the discovery of more barrows in areas of Farmland Medieval, where regular ploughing over a long period will have levelled any

surviving sites: 47% of known cropmark barrows are located within this HLC Type. 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 at a more recent date and therefore one can assume a greater level of below-ground survival of archaeological deposits here compared with areas of Farmland Medieval. However 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. If these two types are considered to be the zone of high probability their performance is summarised in the table below.

Probability zone	PA	PS	Kvamme's gain
High	0.2675	0.4447	0.3985

Although the probability zone only captures 44% of the barrows it is relatively precise and consequently produces a reasonable Kvamme's gain value. For cropmark barrows, then, the most practical model would consist of a high probability zone made up of the HLC Types Farmland Post Medieval and Farmland C20 (and possibly Coastal Rough Ground), and an 'above average' probability zone comprising Farmland Medieval, Farmland Prehistoric, ornamental and Upland Rough Ground.

8.4.2 Conclusions

- The high level model for Bronze Age barrows based on the 1994 HLC suggests that the HLC Types where the barrows are most likely to be found are, in order of importance; Farmland Post Medieval, Farmland C20, Coastal Rough Ground, Upland Rough Ground and Farmland Prehistoric. Small numbers of barrows are located in HLC Types Settlement C20, Rough Ground/Industrial and Recreational.
- The model is reasonably accurate: 63% of the sites are captured in the high probability zone.
- The model is reasonably precise: the high probability zone covers 37% of the project area.
- The majority of barrows (55%) in the high probability zone have above ground extant remains as opposed to 15% recorded as cropmarks. Only 19% of barrows in the dataset are recorded as cropmarks.
- Given the high proportion of extant barrows in the dataset it is possible that the distribution of known barrows is biased towards those areas where extant remains are most likely to survive – i.e. in Rough Ground and parts of Farmland Post Medieval and Farmland C20 which were formerly Rough Ground.
- Cropmark barrows are most likely to be found in the HLC Types Farmland Post Medieval and Farmland C20. This suggests that, despite the large numbers of barrows in Farmland Medieval (and the possibility that more may remain undiscovered in this HLC Type), Rough Ground and former Rough Ground were the favoured landscape setting for Bronze Age barrows.

8.5 Early medieval settlements

The dataset for early medieval sites, filtered as described in section 5.1.5, contained 2116 site records in total. Their distribution is shown in Fig 30. As can be seen there are very dense concentrations of sites in places, interspersed with blank areas. For the most part these gaps in distribution coincide with areas of high ground.

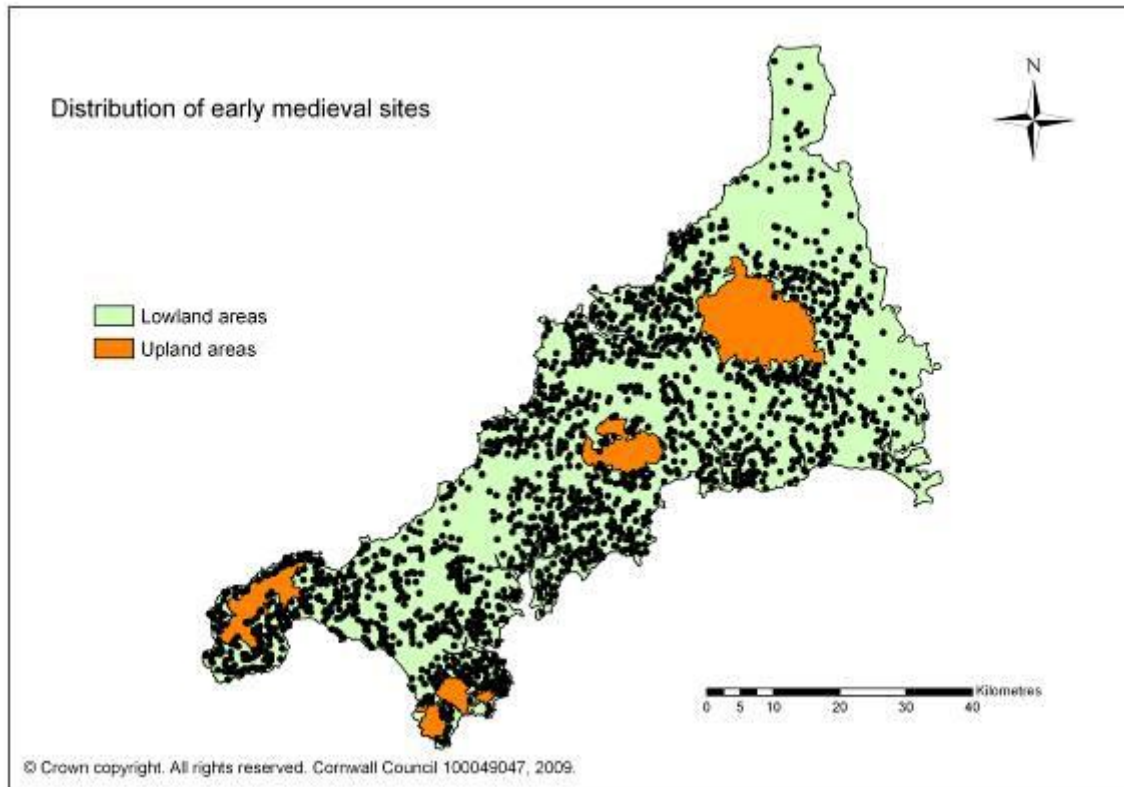


Fig 30. Distribution of early medieval sites in the Lowland Cornwall project area.

The dataset is formed by a range of site types. Those for which there are more than 10 records in the dataset are listed below.

Cemetery	28
Chapel	18
Church	11
Cross	39
Field system	14
Find spot	47
Holy well	14
Inscribed stone	59
Lann	144
Linear earthwork	16
Manor	114
Monastery	16
Occupation site	13
Settlement	1,486

In total the Lowland Cornwall dataset contains 1,486 records for the site type settlement whose period is early medieval. Of these, one is recorded as a cropmark, two are identified from artefact scatters, 19 are recorded as extant sites, 10 are known to be the site of former settlements which have since been destroyed and the remaining 1,454 (77%) 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). The distribution of early medieval settlements (Fig 31) closely replicates that of the entire early medieval dataset (Fig 30). There are also general similarities between the distribution of early medieval settlements with that of rounds and enclosures, in that there is a notable bias towards western and central areas at the expense of east Cornwall. However the lower number of recorded settlements in the east can be explained in part by the predominance of English place-names here. The consequent paucity of Cornish place-names means fewer settlements can be confidently ascribed early medieval origins.

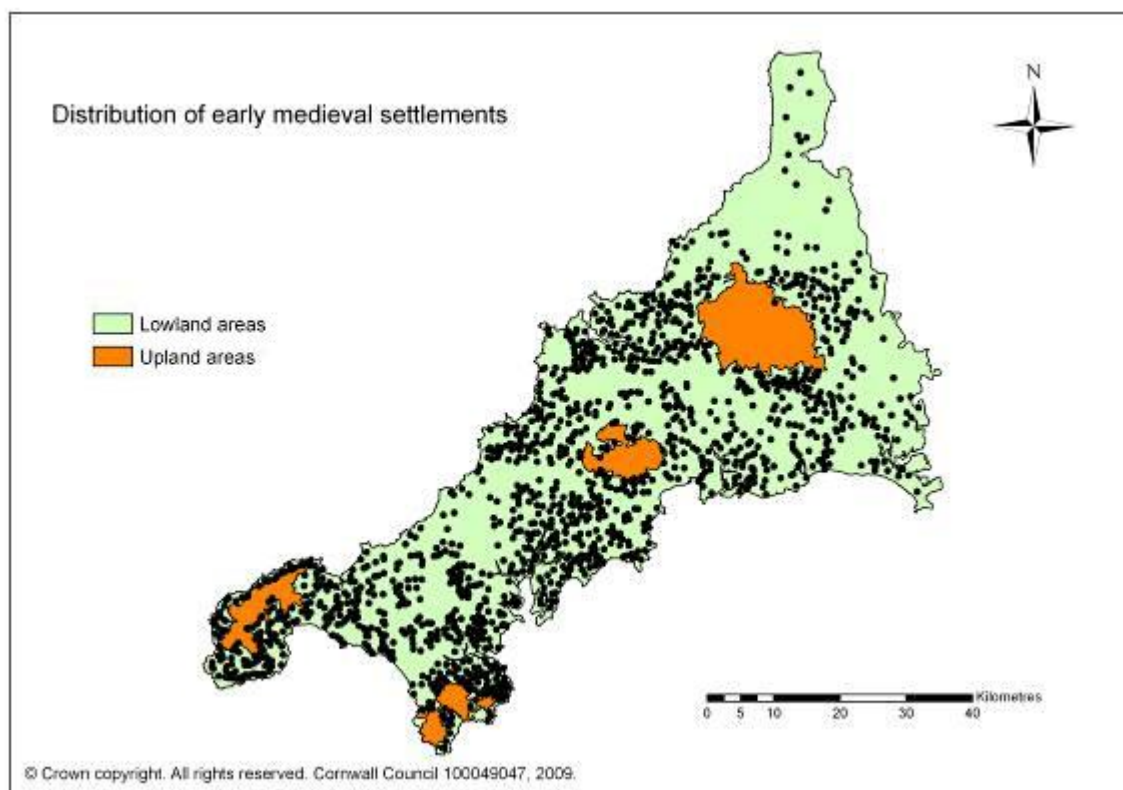


Fig 31. Distribution of early medieval settlements in the Lowland Cornwall project area.

The high level model based on their distribution correlated with HLC Types is summarised in table 31 below.

Early medieval settlements: High probability zone				
HLC Type	Sites	PA	PS	Cum Kj
Farmland Medieval	977	0.5215	0.6575	0.2989
Farmland Prehistoric	116	0.0275	0.0781	0.3704
Settlement C20	107	0.0309	0.0720	0.4288
Ornamental	37	0.0137	0.0249	0.4459
Total	1237	0.5936	0.8325	

Early medieval settlements: Medium probability zone				
HLC Type	Sites	PA	PS	Cum Kj
Farmland C20	80	0.1076	0.0538	0.4050
Settlement older core	17	0.0052	0.0114	0.4144
Plantation and Scrub	27	0.0362	0.0182	0.3984
Recreational	13	0.0062	0.0087	0.4032
Communications	10	0.0042	0.0067	0.4076
Total	147	0.1594	0.0988	

Table 31. High and medium probability zones of the high level model for early medieval settlements in lowland Cornwall.

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. Farmland Post Medieval is ranked in the low probability zone. The performance of the model is summarised in the table below.

Probability zone	PA	PS	Kvamme's gain	PS/PA
High	0.5936	0.8324	0.2869	1.40
Medium	0.1593	0.0989	-0.6108	0.62
Low	0.2470	0.0686	-2.5990	0.28

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); and 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 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) and whose field patterns are morphologically distinct from the generally straight-sided fields of later enclosure' (Herring 1994). 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 32.

A number of site types other than 'settlement' represent early medieval settlement sites. These include nine records for 'building', five for 'house', 114 records for 'manor' and 13 for 'occupation site'. Of the buildings, seven of the nine are captured in the high probability zone - six are within Settlement C20 and one in Farmland Medieval. The other two are in Coastal Rough Ground (Trevelgue Head) or Dunes (St Pirans Oratory).

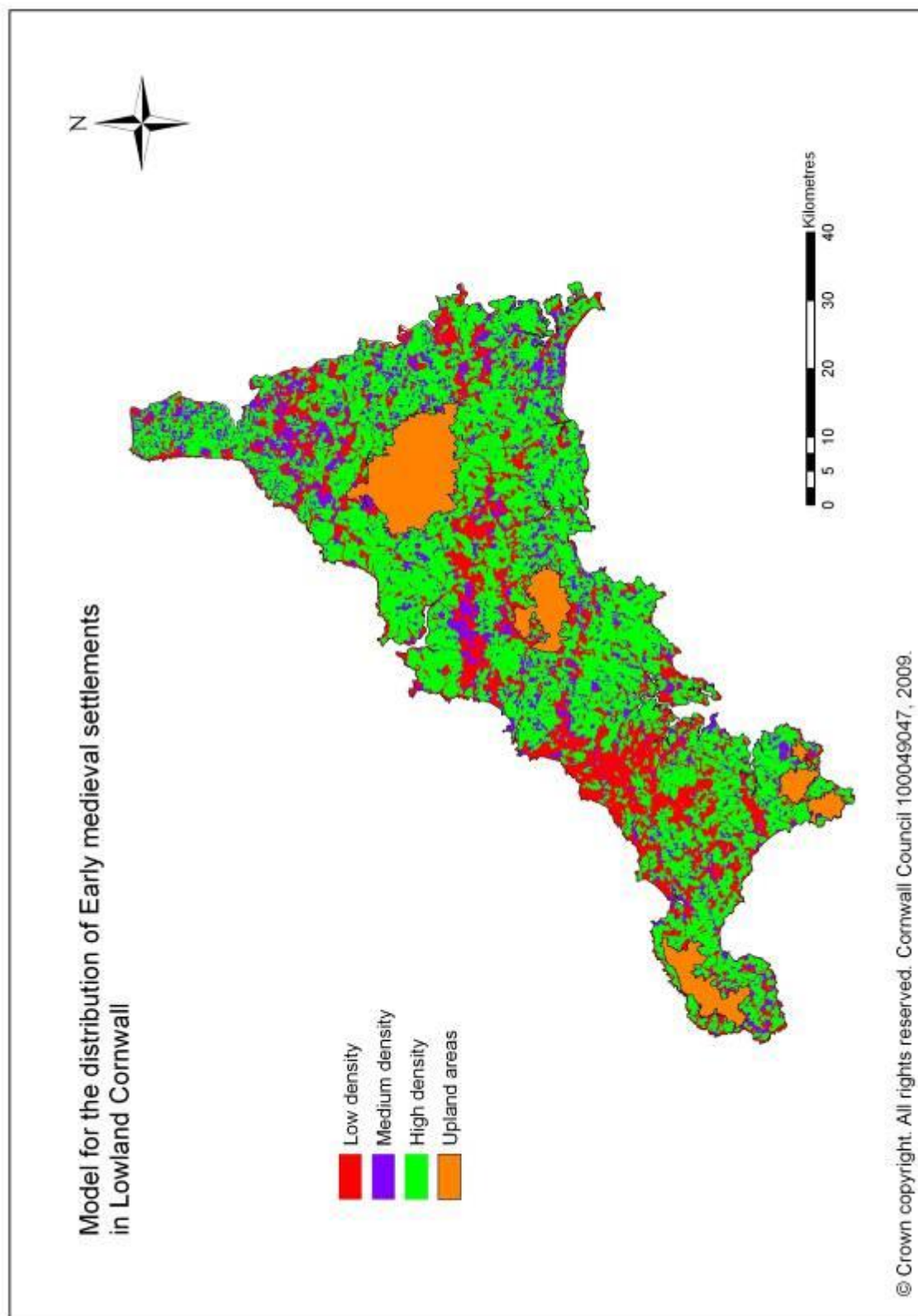


Fig 32. Probability map based on the high level HLC model for early medieval settlements in Lowland Cornwall.

One of the houses is within the HLC Type 'Dunes' (Gwithian site GM/1); the other four are all within Farmland Medieval. Only one of the occupation sites is captured in the high probability zone (the site at Mawgan Porth which lies within Settlement C20): two

are in Coastal Rough Ground (Tintagel and Maen Castle), four are in Dunes (all at Gwithian), four are in Farmland C20, one is in Plantation and Scrub, and one in Settlement older core. Significantly, however, 91% of early medieval manors are captured in the high probability zone. The correlation of manor sites and HLC Types is summarised in table 32 below.

Probability zone	HLC Type	No. of sites
High	Farmland Medieval	100
	Ornamental	3
	Settlement C20	1
Total for high probability zone		104
Medium	Farmland C20	3
	Plantation and Scrub	2
	Settlement older core	2
Total for medium probability zone		7
Low	Farmland Post Medieval	3
Total for low probability zone		3

Table 32. Early medieval manor sites and probability zones of the early medieval settlement model.

So, out of the 141 settlement sites which are listed as site types other than 'settlement', 116 (82%) are captured in the high probability zone, 13 (9%) are captured in the medium probability zone and 12 (9%) in the low probability zone. This corroborates very closely the performance of the early medieval settlement model, the only difference being that the low probability zone performs slightly better (with 9% of the sites rather than 7%) at the expense of the other two probability zones.

8.5.1 Conclusions

- The high level model for early medieval settlements based on the 1994 HLC suggests that the HLC Types where the settlements are most likely to be found are, in order of importance; Farmland Medieval, Farmland Prehistoric, Settlement C20 and Ornamental.
- The model is accurate: 83% of the sites are captured in the high probability zone, and this result is corroborated when tested with the distribution of early medieval buildings, houses, manors and occupation sites.
- This is to be expected because the location of early medieval settlements was one of the pieces of evidence used to define the HLC Type Farmland Medieval during the 1994 HLC project.
- The model is not very precise: the high probability zone covers 59% of the project area, thereby producing a moderate Kvamme's gain. This is due to the large area covered by the HLC Type Farmland Medieval

8.6 Prehistoric and Romano-British find spots

8.6.1 Prehistoric and Romano-British find spots

HER data for finds was processed in two ways to deal with the extensive multiple-indexing of site records (see section 5.1.4). 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. In cases where the period was interpreted as, for instance, either Neolithic or Bronze Age then this site will appear in both the Neolithic and the Bronze Age data sets.

In total the dataset contains 1,872 records for prehistoric and Romano-British find spots reduced to a single point per site find spots. Their distribution is shown in Fig 33.

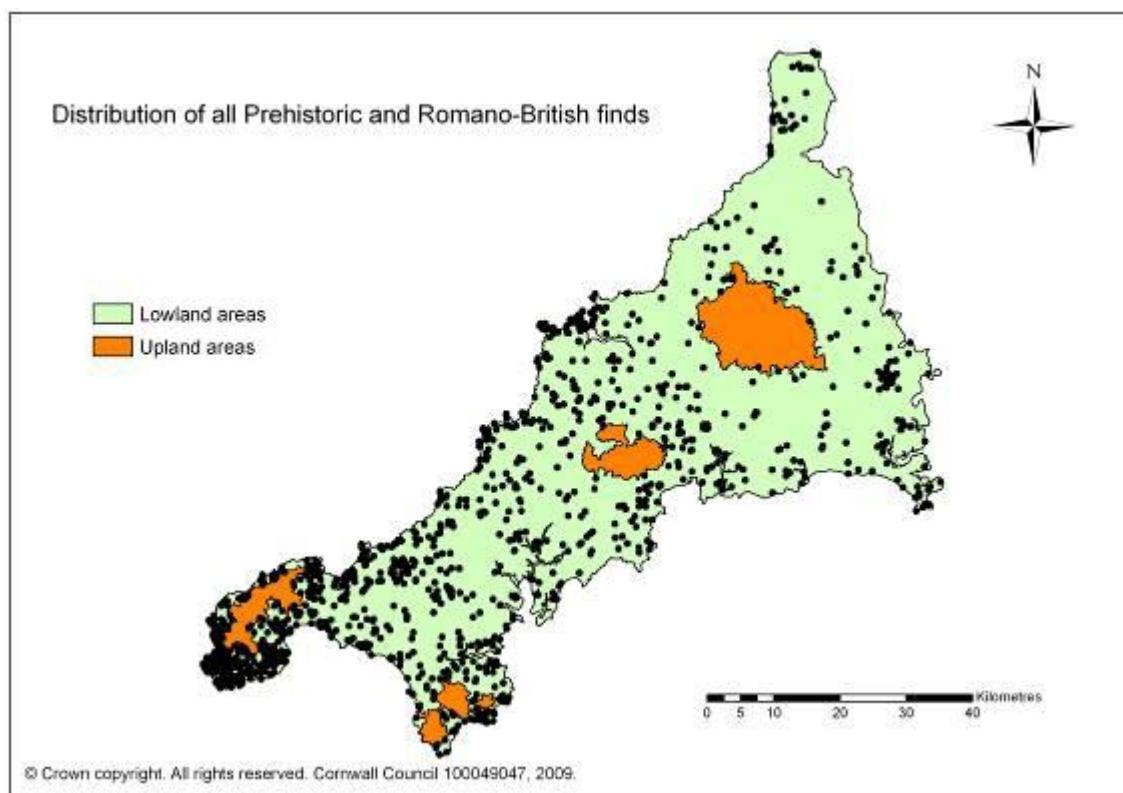


Fig 33. Distribution of all prehistoric and Romano-British find spots in the Lowland Cornwall project area.

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 recorded find spots in east Cornwall than elsewhere.

The model for all prehistoric and Romano-British find spots reduced to a single point per site is set out in table 33 below.

Prehistoric and Romano-British find spots: high probability zone				
HLC Type	Sites	PA	PS	Cum Kj
Farmland Prehistoric	306	0.0275	0.1635	0.1491
Coastal Rough Ground	172	0.0151	0.0919	0.2331
Farmland Post medieval	292	0.1599	0.1560	0.2931
Farmland C20	200	0.1076	0.1068	0.3283
Settlement C20	108	0.0309	0.0577	0.3678
Upland Rough Ground	86	0.0284	0.0459	0.3962
Dunes	42	0.0027	0.0224	0.4188
Settlement older core (pre- 1907)	23	0.0052	0.0123	0.4282
Water: Natural	14	0.0059	0.0075	0.4319
Recreational	12	0.0062	0.0064	0.4341
Total	1255	0.3894	0.6704	
Prehistoric and Romano-British find spots: low probability zone				
HLC Type	Sites	PA	PS	Cum Kj
Farmland Medieval	529	0.5215	0.2826	0.2003
Ornamental	17	0.0137	0.0091	0.1898
Industrial: Disused	9	0.0036	0.0048	0.1934
Water: Reservoirs	7	0.0009	0.0037	0.2007
Ancient Woodland	20	0.0223	0.0107	0.1712
Military	6	0.0055	0.0032	0.1647
Communications	5	0.0042	0.0027	0.1604
Industrial: Working	2	0.0016	0.0011	0.1590
Rough Ground/Industrial	1	0.0012	0.0005	0.1571
Plantation and Scrub	21	0.0362	0.0112	0.0000
Total	617	0.6107	0.3296	

Table 33. High level model for prehistoric and Romano-British find spots reduced to a single point per site.

The model 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. To clarify this point the performance of Farmland Medieval can be quantified using gain measures: Kvamme's gain $(1-(PA/PS)) = -0.8456$ and Relative Gain $(PS-PA) = -0.2390$. By contrast, the highest ranked HLC Type, Farmland Prehistoric produces a Kvamme's gain of 0.8319 and a Relative Gain of 0.1360. Based on the cumulative Kj values (which increase to 0.4341 [Recreational] and then fall sharply to 0.2003 [Farmland Medieval] and do not fall sharply again) a two-zone model more accurately reflects the results of this correlation.

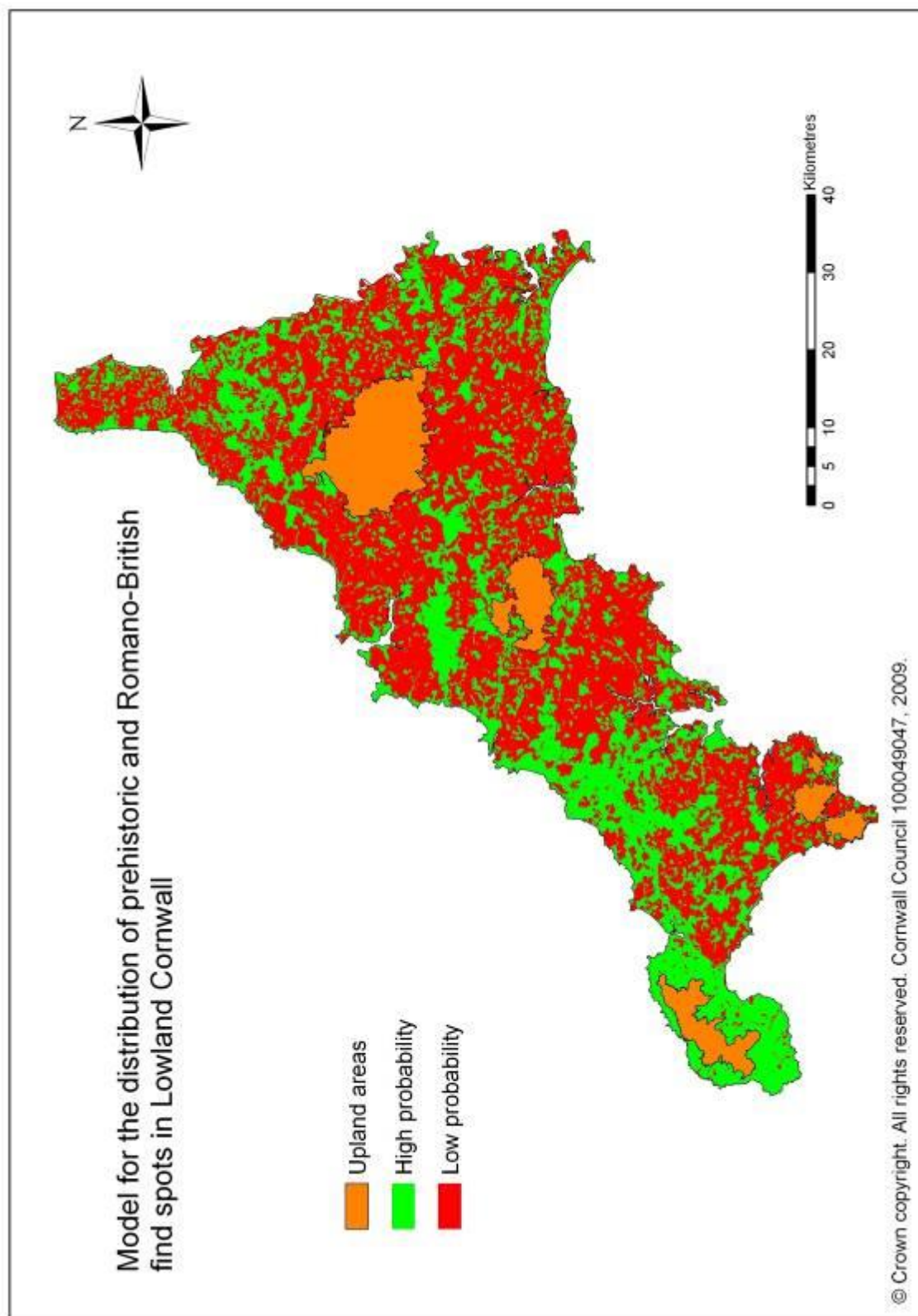


Fig 34. Probability map based on the high level HLC model for prehistoric and Romano-British find spots in Lowland Cornwall.

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 in the table below.

Probability zone	PA	PS	Kvamme's gain	PS/PA
High	0.3893	0.6704	0.4192	1.72
Low	0.6107	0.3296	-0.8527	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 34 below.

The most notable aspect of the distribution of prehistoric finds is the high ranking of the HLC Type Farmland Prehistoric which reflects the dense concentration of records from West Penwith (Fig 33). There are smaller clusters of finds at places along the coast, and in the east around Kit Hill and Viverdon Down.

The overall distribution (and the model itself) is against expectations in that it might be reasonable to suppose that most finds would be made in the HLC Type Farmland Medieval because this is the land class most frequently and intensively ploughed. In the model Farmland Medieval is only ranked twelfth; below Rough Ground Types which are rarely, if ever, ploughed.

The most likely reason for this apparent incongruity is that the distribution reflects the history of field walking and finds collection in Cornwall. In other words the model is primarily retrodictive - effectively predicting the distribution of known finds, or, at the very least, it should be seen as a biased sample, skewed by the areas of activity of a small number of 'serious' finds collectors.

On the other hand, if we accept the assertion that the HLC Type Farmland Medieval represents the area of most intensive prehistoric settlement, then the fact that the finds distribution is contradictory implies significant exploitation of the landscape beyond the intensively settled zone.

8.6.2 Mesolithic find spots

To further examine the distribution of prehistoric finds the data was analysed on a period-by-period basis to see whether the overall distribution modelled above is influenced by finds from one or more particular periods.

The dataset contains only 24 records for Palaeolithic finds which is insufficient to produce valid predictive models. Models were produced, however, for all other periods. In total records for 348 Mesolithic finds (reduced to a single point for each type of material [flint, chert, etc.] per site) are contained in the dataset. The distribution of Palaeolithic and Mesolithic find spots is shown in Fig. 35. Although the main concentration of finds is in West Penwith (as is the case with prehistoric finds generally) the remainder of the find spots are distributed sparsely, with virtually none in east Cornwall. The main foci appear to be certain locations along the north coast, most notably around Padstow, St Agnes and Gwithian. This idiosyncratic distribution is very likely to be reflecting the uneven history of finds collection and a resulting sampling bias.

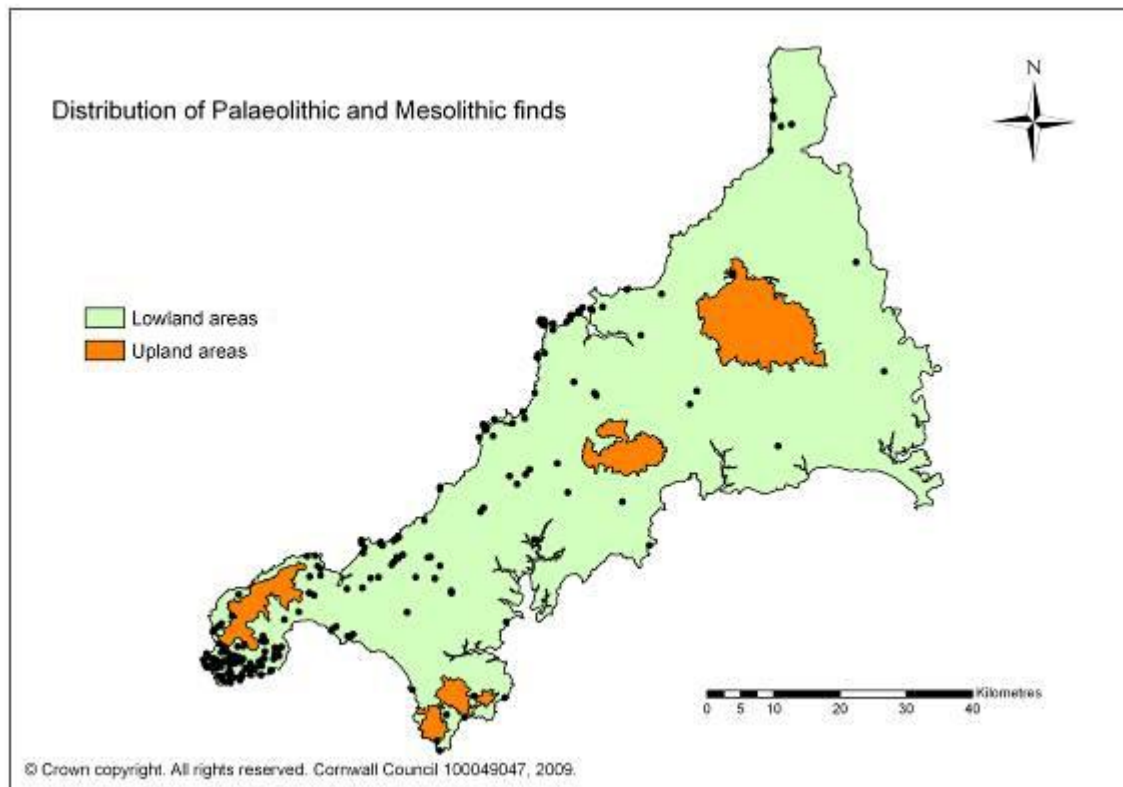


Fig 35. Distribution of all Palaeolithic and Mesolithic find spots in the Lowland Cornwall project area.

The model for Mesolithic finds reduced to a single point for each type of material (flint, chert, etc.) per site is set out in table 34 below.

Mesolithic find spots: high probability zone				
HLC Type	Sites	PA	PS	Cum. Kj
Farmland Prehistoric	93	0.0275	0.2672	0.2531
Farmland C20	71	0.1076	0.2040	0.3980
Farmland Post medieval	78	0.1599	0.2241	0.5277
Coastal Rough Ground	35	0.0151	0.1006	0.6219
Upland Rough Ground	19	0.0284	0.0546	0.6600
Settlement C20	9	0.0309	0.0259	0.6667
Water: Natural	4	0.0059	0.0115	0.6747
Water: Reservoirs	2	0.0009	0.0057	0.6801
Communications	2	0.0042	0.0057	0.6833
Total	313	0.3804	0.8993	

Table 34. High level model for Mesolithic find spots reduced to a single point per site.

The distribution of Mesolithic find spots correlated with HLC produces a two-zone model. The high probability zone is made up of nine HLC Types, listed in table 34 above. The cut off point between this and the low probability zone is the cumulative Kj score of 0.6833. The HLC Type Farmland Medieval is ranked tenth (it contains 31 find spots) and produces a cumulative Kj score of only 0.2928. The probability map for the model is shown in Fig 36 and its performance is summarised below.

Probability zone	PA	PS	Kvamme's gain	PS/PA
High	0.3803	0.9020	0.5784	2.37
Low	0.6197	0.0980	-5.3250	0.16

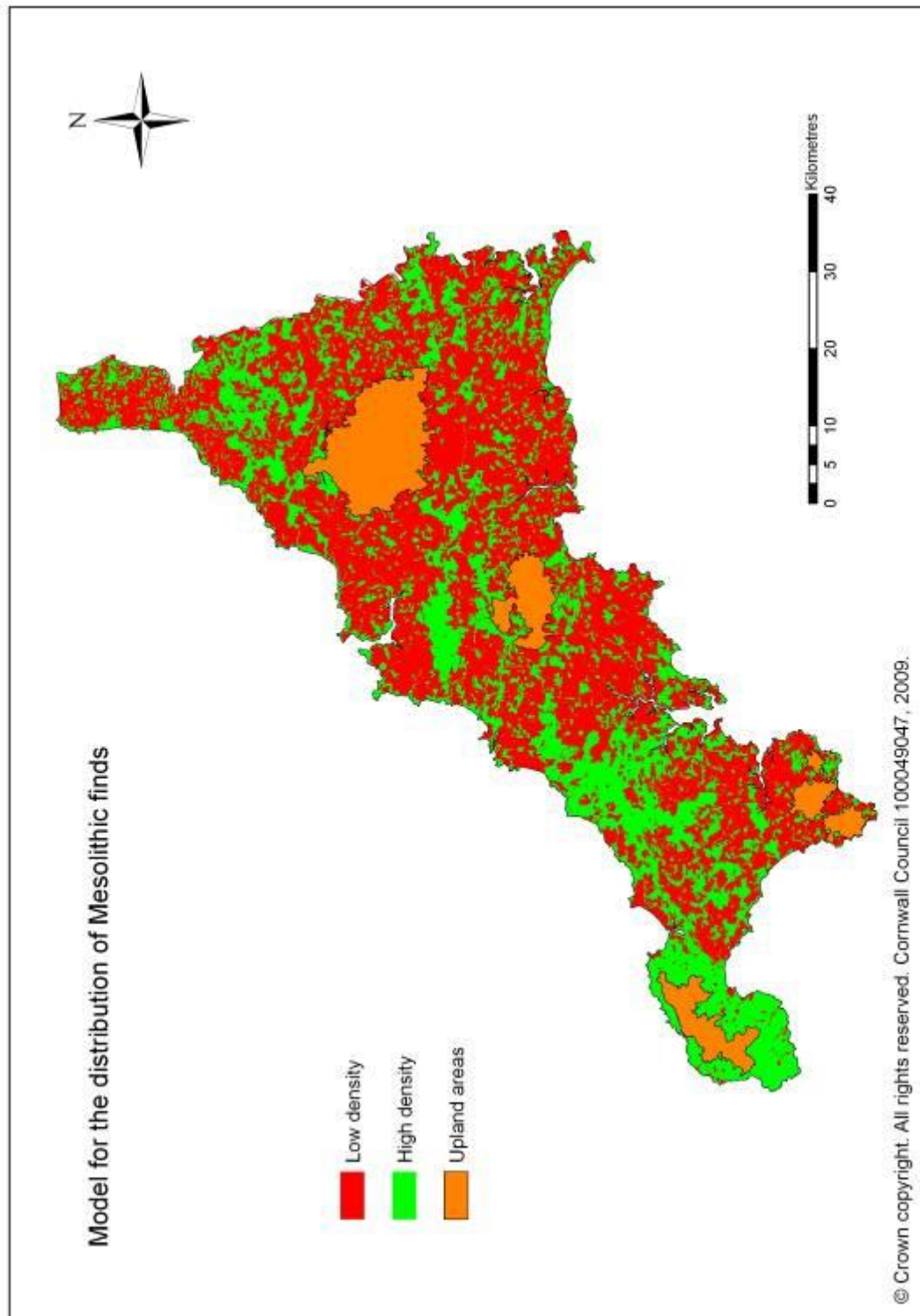


Fig 36. Probability map based on the high level HLC model for Mesolithic find spots in Lowland Cornwall.

The model performs well and is both very accurate and reasonably precise: 90% of the sites are captured in 38% of the project area and only 10% of the sites are captured in the low density zone which covers 62% of the project area. The resulting Kvamme's gain for the high density zone is reasonable.

Overall the model resembles the Prehistoric and Romano-British finds model with Farmland Prehistoric, Farmland C20, Farmland Post medieval and Coastal Rough Ground being the most important HLC Types – although the precise ranking is slightly different in each model. There are differences among some of the smaller HLC Types, such as Dunes and Settlement older core which are in the high density zone in the Prehistoric model but are in the low density zone in the Mesolithic model, and Communications which is in the high density zone in the Mesolithic model.

8.6.3 Neolithic find spots

In total the Lowland Cornwall dataset contains 363 records for Neolithic finds reduced to a single point for each type of material (flint, pottery, etc.). Their distribution differs from that of Mesolithic finds in that, whilst the main concentration of finds is in the southern part of West Penwith, and there are significant clusters at Gwithian and in Gwinear, the remainder of the finds are more widely dispersed throughout the project area, including a number of find spots in east Cornwall. Also there are fewer clusters along the north coast (Fig. 37). In fact the distribution of Neolithic finds is more evenly spread between coastal and inland areas, whereas the Mesolithic find spots have a more obviously coastal distribution.

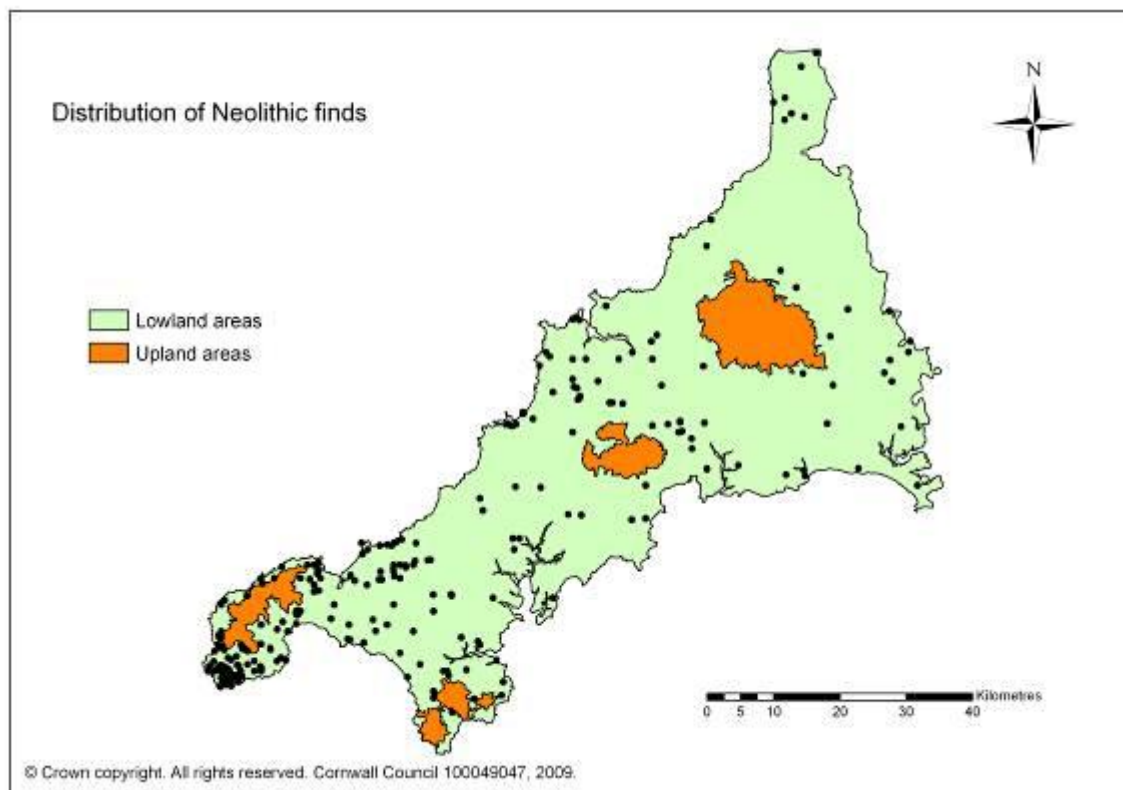


Fig 37. Distribution of all Neolithic find spots in the Lowland Cornwall project area

The model resembles the previous two finds distribution models, with Farmland Prehistoric, Farmland C20 and the Rough Ground Types ranked highest. This model does differ somewhat to that for Mesolithic finds in that more of the smaller HLC Types fall into the high density zone (table 35).

Like other models for finds distribution it is not practical to define a cut off point for any medium probability zone and again this model results in only two zones (high and low

probabilities). The HLC Type ranked immediately below Water: Reservoirs is Farmland Medieval which produces a cumulative Kj score of only 0.1490 (a significant drop from the 0.4567 produced by the high probability zone). There are, however more Neolithic find spots recorded from Farmland Medieval than from any other HLC Type (98 recorded find spots).

Neolithic find spots: high probability zone				
HLC Type	Sites	PA	PS	Cum. Kj
Farmland Prehistoric	85	0.0275	0.2225	0.2083
Upland Rough Ground	33	0.0284	0.0864	0.2796
Farmland C20	49	0.1076	0.1283	0.3459
Coastal Rough Ground	18	0.0151	0.0471	0.3848
Farmland Post medieval	46	0.1599	0.1204	0.4013
Settlement C20	20	0.0309	0.0524	0.4348
Settlement older core	5	0.0052	0.0131	0.4451
Industrial: Disused	4	0.0036	0.0105	0.4537
Dunes	3	0.0027	0.0079	0.4602
Plantation and Scrub	8	0.0362	0.0209	0.4555
Water: Natural	2	0.0059	0.0052	0.4566
Ornamental	3	0.0137	0.0079	0.4545
Water: Reservoirs	1	0.0009	0.0026	0.4567
Total	277	0.4376	0.7252	

Table 35. High level model for Neolithic find spots reduced to a single point per site.

There are inconsistencies in the cumulative Kj values in this model. The values increase to 0.4602 (Dunes), then fall to 0.4555 (Plantation and Scrub) before rising again to 0.4566 (Water: Natural), falling to 0.4545 (Ornamental) and increasing once more to 0.4567 (Water: Reservoirs). To some extent the rankings of the HLC Types in question are interchangeable but, as these are all relatively small HLC Types the inconsistencies should be seen as minor and not detracting from the overall meaning of the model.

The performance of the model is summarised in the table below.

Probability zone	PA	PS	Kvamme's gain	PS/PA
High	0.4375	0.7251	0.3967	1.66
Low	0.5625	0.2749	-1.0464	0.49

Despite a modest Kvamme's gain this model can be said to perform reasonably well. It is accurate with 72.5% of the sites captured in the high density zone. The main issue is that although Farmland Medieval contains more sites than any other HLC Type it must clearly be included in the low site density zone.

The probability map produced by this model is virtually identical to that produced by the distribution of Mesolithic finds and is therefore not shown here.

8.6.4 Bronze Age find spots

The Lowland Cornwall dataset contains a total of 283 records for Bronze Age finds reduced to a single point for each type of material (flint, pottery, etc.) per site.

The distribution of Bronze Age finds follows the general trends for prehistoric finds, with the main concentration in West Penwith. There is a notable lack of sites in east

Cornwall, but overall the finds are dispersed more widely throughout the project area than those of earlier periods (Fig. 38).

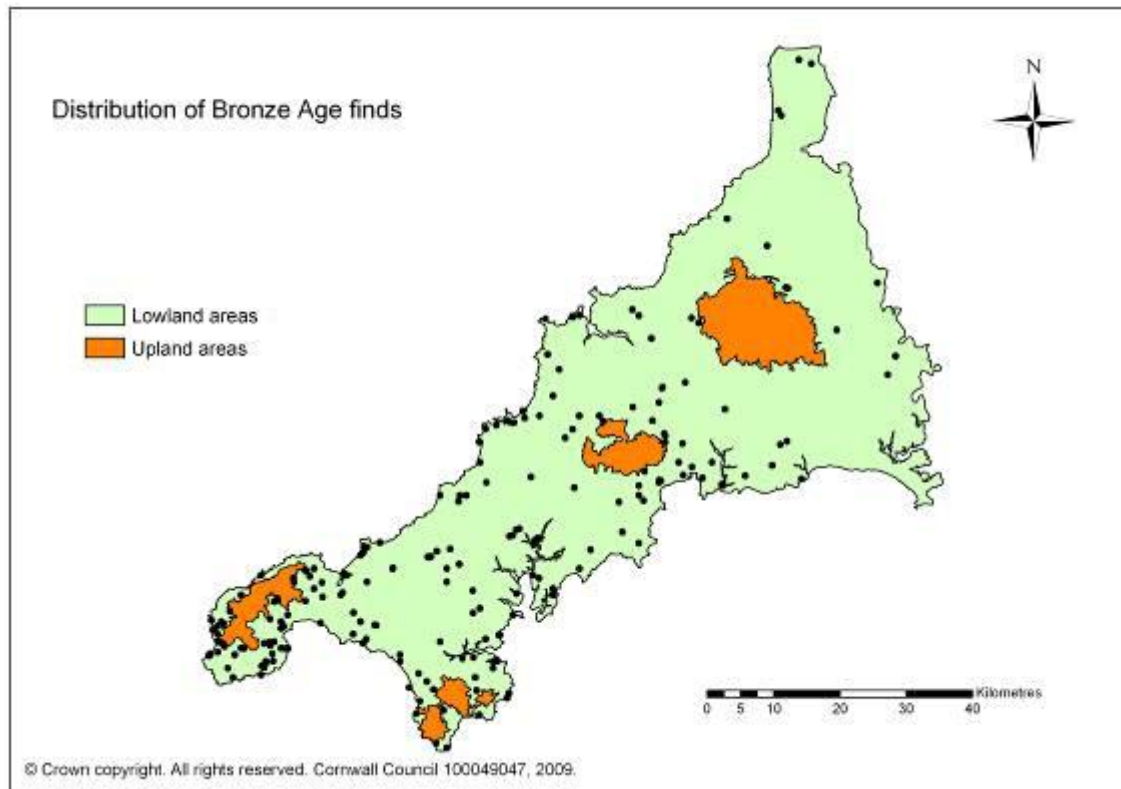


Fig 38. Distribution of all Bronze Age find spots in the Lowland Cornwall project area

Bronze Age find spots: high probability zone				
HLC Type	Sites	PA	PS	Cum. Kj
Farmland Prehistoric	46	0.0275	0.1484	0.1339
Coastal Rough Ground	29	0.0151	0.0935	0.2196
Settlement C20	29	0.0309	0.0935	0.2965
Farmland C20	33	0.1076	0.1065	0.3396
Farmland Post medieval	40	0.1599	0.1290	0.3624
Upland Rough Ground	14	0.0284	0.0452	0.3900
Dunes	5	0.0027	0.0161	0.4056
Settlement older core (pre- 1907)	5	0.0052	0.0161	0.4193
Total	201	0.3773	0.6483	

Table 36. High level model for Bronze Age find spots reduced to a single point per site.

The high probability zone of this model is made up of eight HLC Types, with a cumulative Kj score of 0.4193. The HLC Type ranked ninth is Farmland Medieval which contains 92 recorded Bronze Age find spots – more than any other HLC Type (and twice as many as Farmland Prehistoric, which contains the next highest number of sites). It is possible to define a medium density zone comprising Farmland Medieval, but the cumulative Kj score for this Type is 0.2094. This results in a weak model with the Farmland Medieval HLC Type, forming a very large medium density zone. Therefore a

more satisfactory outcome is a two-zone model, whose performance is summarised in the table below.

Probability zone	PA	PS	Kvamme's gain	PS/PA
High	0.3772	0.6484	0.4182	1.72
Low	0.6228	0.3516	-0.7711	0.56

The model performs reasonably well, with two thirds of the find spots in the high probability zone which covers only a third of the project area. Conversely the low probability zone covers two thirds of the project area but only captures one third of the sites. The model is similar to other prehistoric finds models in that the most important HLC Types are the same and the highest ranked Type is Farmland Prehistoric. The precise ranking of the important Types is, however, slightly different and Settlement C20 is ranked as high as third. This high ranking of Settlement C20 is probably due to archaeological interventions during urban development.

Because of its similarity to other prehistoric find spot models the probability map produced by this model is not shown here.

8.6.5 Find spots ascribed a generic prehistoric date

A total of 620 records for prehistoric finds interpreted with the generic period 'Prehistoric' are contained in the Lowland Cornwall dataset. The distribution of these records, reduced to a single point for each type of material (flint, pottery, etc.) per site, is shown in Fig. 39.

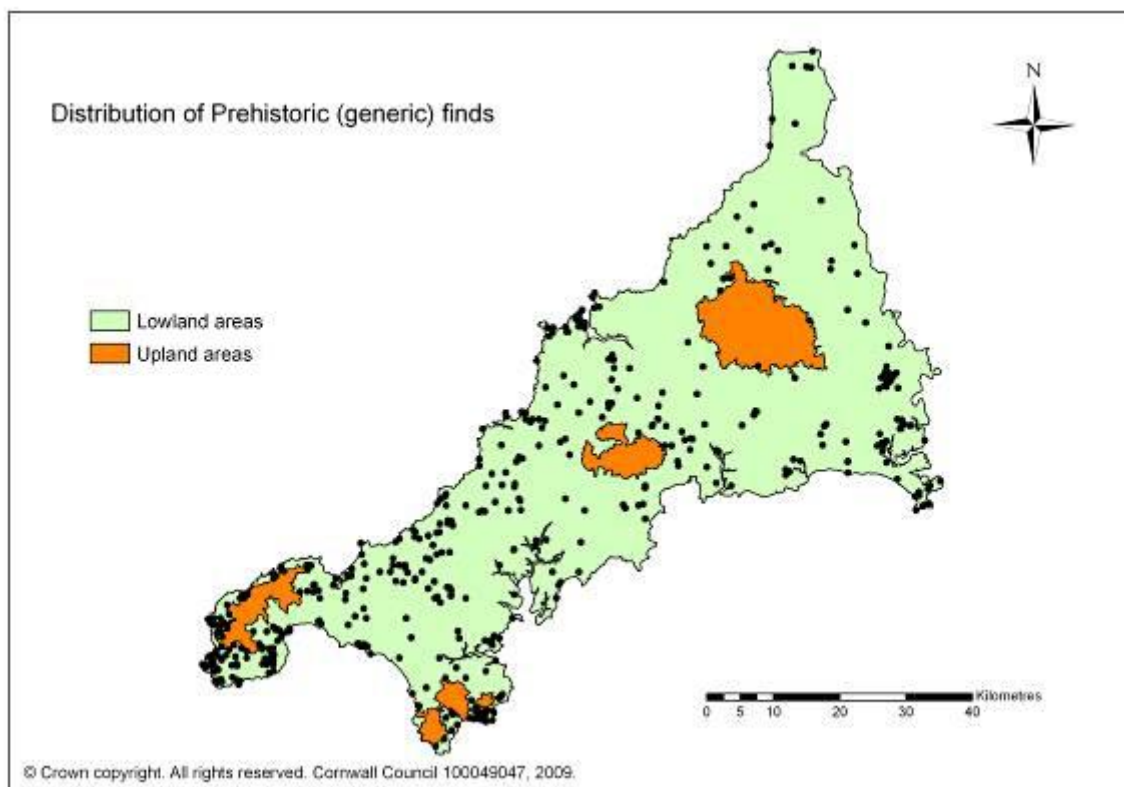


Fig 39. Distribution of all Prehistoric (generic) find spots in the Lowland Cornwall project area.

Finds ascribed a generic prehistoric date are more widespread throughout lowland Cornwall than those specifically dated to Mesolithic, Neolithic or Bronze Age (compare

Fig. 39 with Figs 35, 37 and 38). However, there are several features of the distribution which are common to all finds distributions – the concentrations in West Penwith, the Lizard Peninsula and in places on the north coast.

The high level model for generic prehistoric finds is shown in table 37 below.

Generic prehistoric find spots: high probability zone				
HLC Type	Sites	PA	PS	Cum. Kj
Farmland Prehistoric	75	0.0275	0.1210	0.1063
Farmland Post medieval	119	0.1599	0.1919	0.1982
Coastal Rough Ground	58	0.0151	0.0935	0.2879
Farmland C20	69	0.1076	0.1113	0.3279
Settlement C20	38	0.0309	0.0613	0.3713
Upland Rough Ground	15	0.0284	0.0242	0.3756
Dunes	8	0.0027	0.0129	0.3878
Settlement older core (pre- 1907)	8	0.0052	0.0129	0.3980
Total	390	0.3773	0.629	
Generic prehistoric find spots: medium probability zone				
HLC Type	Sites	PA	PS	Cum. Kj
Farmland Medieval	196	0.5215	0.3161	0.2094
Industrial: Disused	4	0.0036	0.0065	0.2165
Military	4	0.0055	0.0065	0.2192
Water: Natural	4	0.0059	0.0065	0.2212
Water: Reservoirs	3	0.0009	0.0048	0.2302
Ornamental	5	0.0137	0.0081	0.2189
Total	216	0.5511	0.3485	

Table 37. High level model for generic prehistoric find spots reduced to a single point per site.

All other HLC Types make up the low probability zone.

Unlike other models for prehistoric find spots there is a clearly definable medium probability zone in this model. Cumulative Kj values for the high probability zone rise to 0.3980, then drop to 0.2094 to form the cut off point between the high and medium zones. The Kj values for the medium probability zone rise to 0.2189 and then fall to 0.1597, indicating the cut off point between the medium and low zones. The performance of the model is summarised in the table below.

Probability zone	PA	PS	Kvamme's gain	PS/PA
High	0.3772	0.6290	0.4003	1.67
Medium	0.5512	0.3484	-0.5821	0.63
Low	0.0716	0.0226	-2.1702	0.32

Although the high probability zone performs reasonably well, capturing 63% of sites in 38% of the project area, the model is quite weak owing to the inclusion of the HLC Type Farmland Medieval in the medium probability zone. This means that the medium zone (the zone of neutral probability) covers more than half the project area. The low density zone is accurately and precisely defined in this model. The model indicates that the chances of encountering a prehistoric find spot in the high probability zone are 2.6

times higher than in the medium probability zone and five times higher than in the low probability zone. The probability map produced by this model is shown in Fig 40.

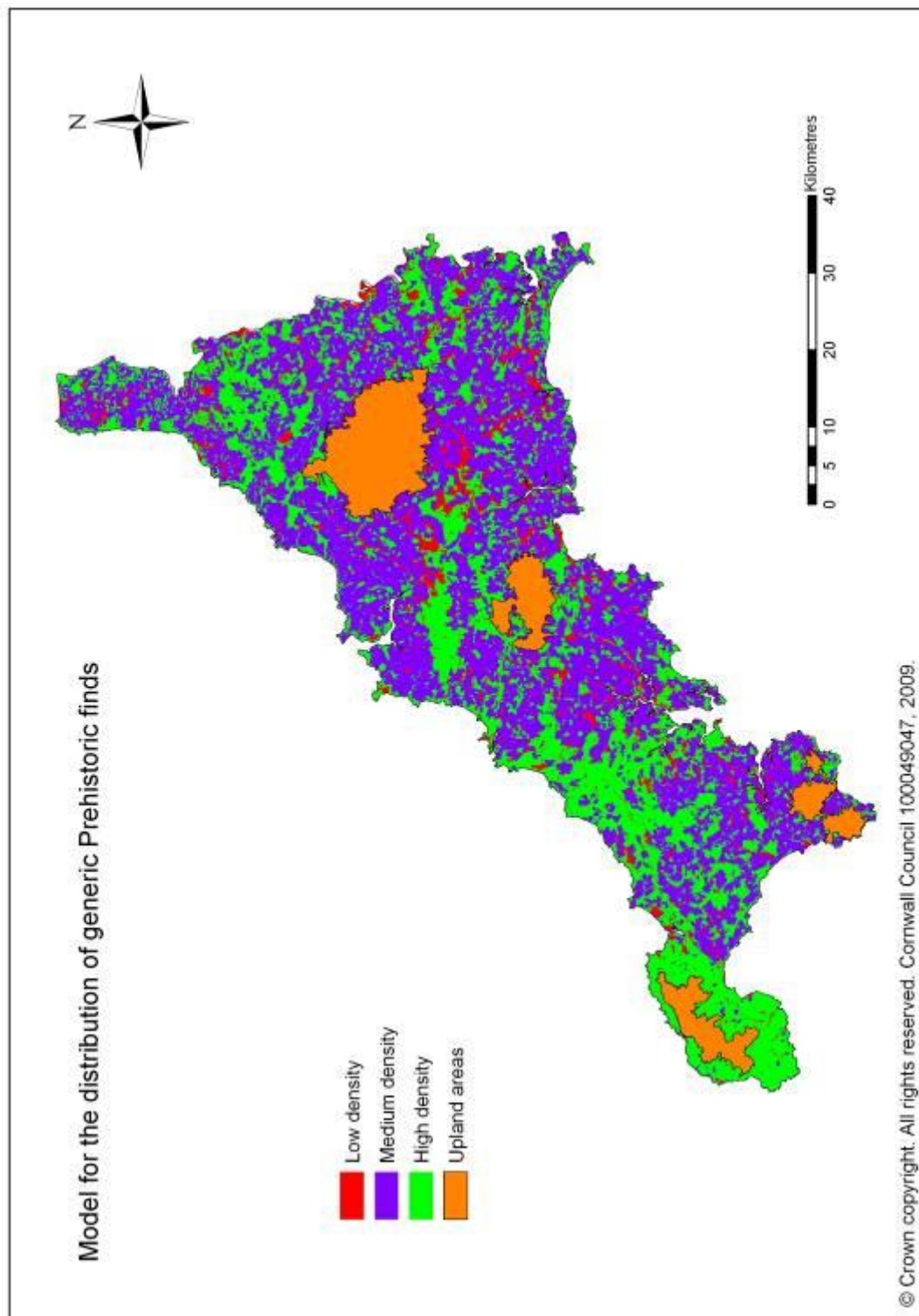


Fig 40. Probability map based on the high level HLC model for generic prehistoric find spots in Lowland Cornwall.

8.6.6 Iron Age and Romano-British find spots

There are 325 Iron Age or Romano-British find spots recorded in the dataset and their distribution is shown in Fig. 41. This distribution is marked by concentrations in West Penwith, around the Helford and Fowey valleys, and at a number of locations on the north coast. There are notably fewer sites in east Cornwall.

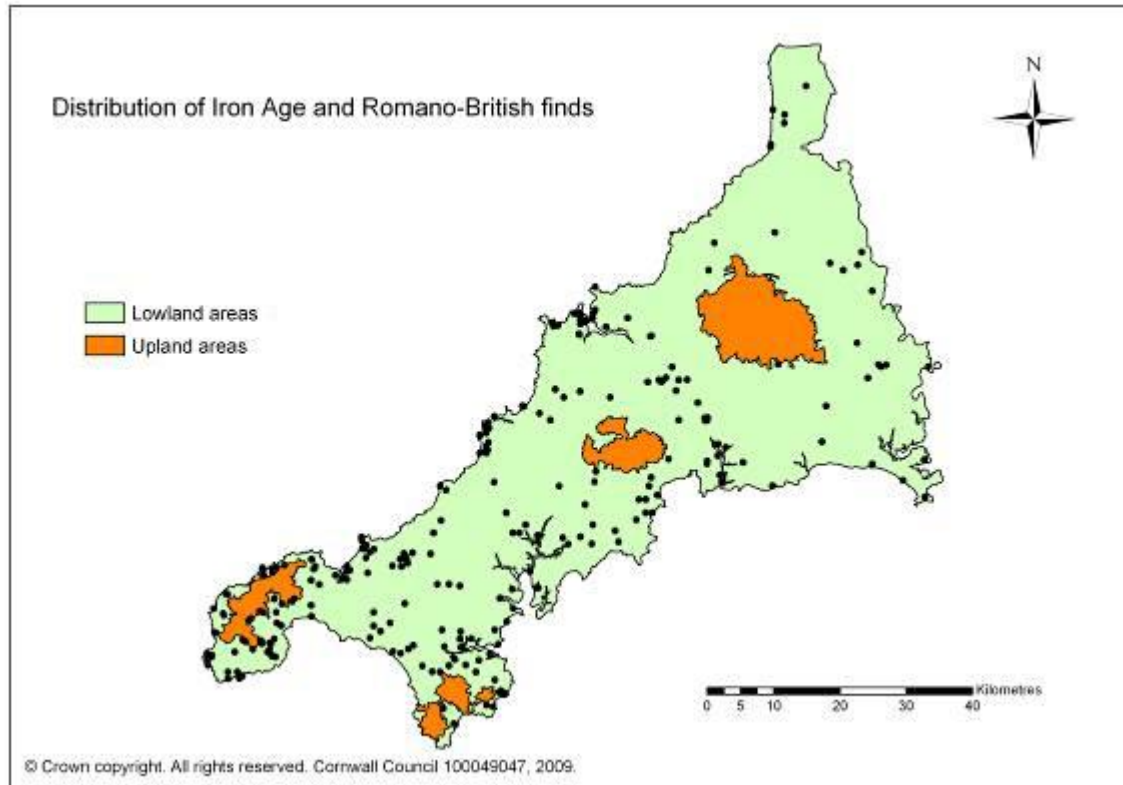


Fig 41. Distribution of all Iron Age and/or Romano-British find spots in the Lowland Cornwall project area.

The model for Iron Age and Romano-British find spots is set out in table 38 below.

Iron Age and Romano-British find spots: high probability zone				
HLC Type	Sites	PA	PS	Cum. Kj
Farmland Prehistoric	41	0.0275	0.1262	0.1116
Coastal Rough Ground	37	0.0151	0.1138	0.2177
Settlement C20	27	0.0309	0.0831	0.2840
Dunes	12	0.0027	0.0369	0.3197
Upland Rough Ground	14	0.0284	0.0431	0.3469
Settlement older core (pre- 1907)	10	0.0052	0.0308	0.3750
Recreational	8	0.0062	0.0246	0.3963
Farmland C20	23	0.1076	0.0708	0.4022
Water: Natural	5	0.0059	0.0154	0.4143
Ornamental	5	0.0137	0.0154	0.4212
Total	182	0.2432	0.5601	

Iron Age and Romano-British find spots: medium probability zone				
HLC Type	Sites	PA	PS	Cum. Kj
Farmland Medieval	99	0.5215	0.3046	0.2939
Ancient Woodland	5	0.0223	0.0154	0.2861
Total	104	0.5438	0.32	

Table 38. High level model for Iron Age and Romano-British find spots reduced to a single point per site.

All other HLC Types make up the low probability zone.

Unlike most of the models for prehistoric find spots there is a clearly definable medium probability zone in this model. Cumulative Kj values for the high probability zone rise to 0.4212, then drop to 0.2939 to form the cut-off point between the high and medium zones. The Kj values for the medium probability zone fall to 0.2861 and then drop suddenly to 0.1571, indicating the cut-off point between the medium and low zones. The performance of the model is summarised in the table below.

Probability zone	PA	PS	Kvamme's gain	PS/PA
High	0.2431	0.5600	0.5658	2.30
Medium	0.5439	0.3200	-0.6996	0.59
Low	0.2130	0.1200	-0.7750	0.56

This model is not very accurate in that only 56% of the sites are captured in the high probability zone. This zone is relatively small (covering only 24% of the project area) and consequently is precise and so produces a reasonable Kvamme's gain. The low probability zone is accurately defined capturing only 12% of the sites, and covers 21% of the project area. The great weakness of the model lies in the large size of the medium probability or neutral zone (due to the size of the HLC Type Farmland Medieval). In effect this means that HLC in nearly half of the project area has little predictive power. Even so the ratio of Indicative Values indicates that the probability of encountering a site in the high density zone is almost four times higher than in the medium density zone and more than four times higher than in the low density zone. The probability of encountering a site in the medium density zone is similar to that in the low density zone.

The model is broadly similar to the other models for find spots in that the HLC Type Farmland Prehistoric is ranked highest and the high probability zone is made up of Types such as Coastal and Upland Rough Ground, Settlement C20 and Dunes. One significant difference is that the HLC Type Farmland Post medieval forms part of the low probability zone, whereas in all the other find spot models this Type is included in the high probability zone. The probability map produced by this model is shown in Fig 42.

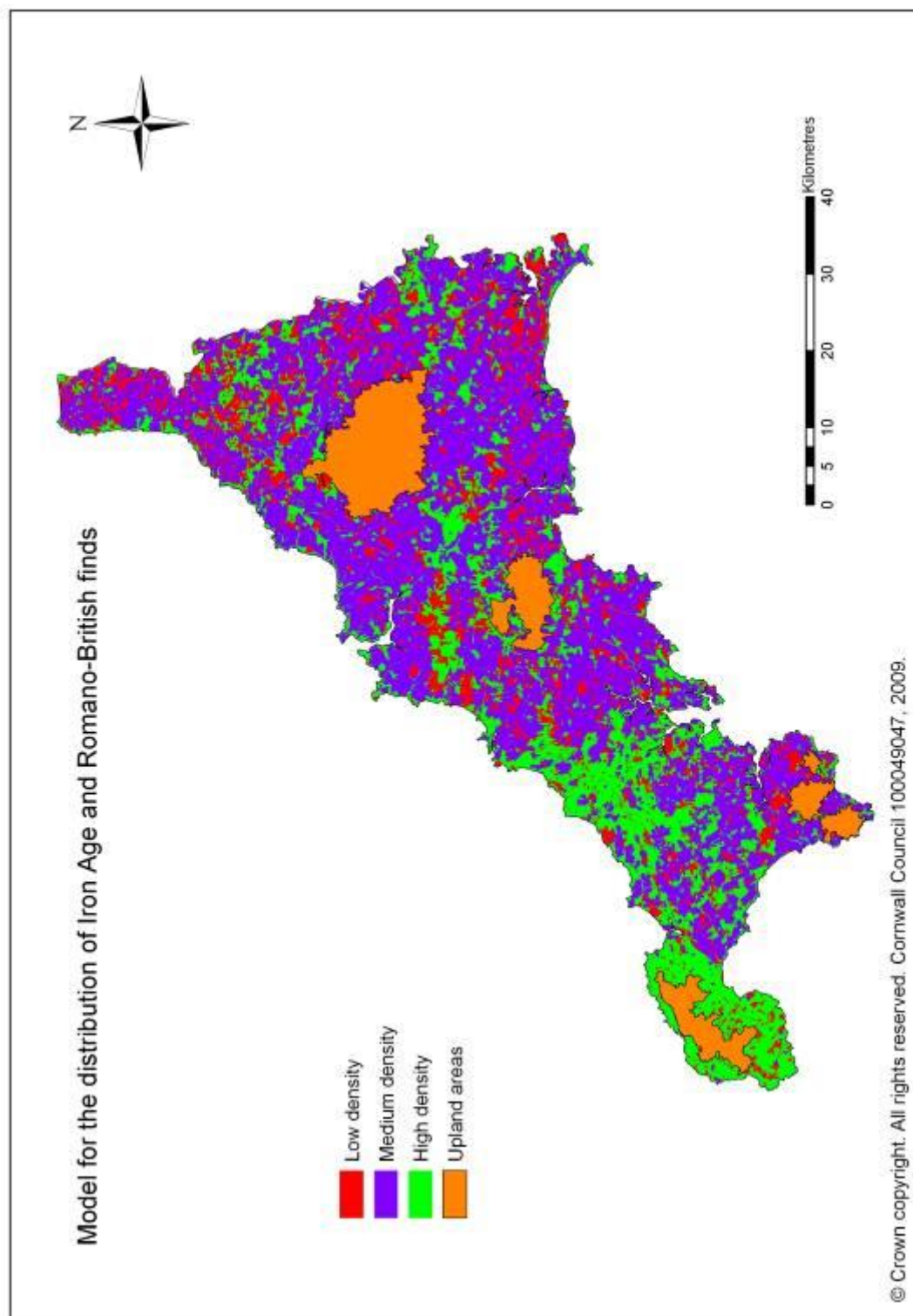


Fig 42. Probability map based on the high level HLC model for Iron Age and Romano-British find spots in Lowland Cornwall.

8.6.7 Portable Antiquities Scheme data

In total there are 231 find spots recorded in the Portable Antiquities Scheme dataset for lowland Cornwall and their distribution is shown in Fig 43. It should be stressed that PAS data does not constitute a representative sample in that most of the records result from the activities of a small number of finds collectors at favoured locations. These are centred around Ludgvan, Phillack Towans, Padstow, Tregony, Gorran and Mevagissey, and the Fowey Valley. There are very few sites in east and southeast Cornwall. In fact the finds all come from only 54 sites 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). To some extent all the distribution patterns for find spots are influenced by the work of individual finds collectors and this is particularly the case with PAS finds. Even more than the other models for find spot distribution this model is retrodictive is based on a biased sample.

Most of the finds are Romano-British: a breakdown of the finds by date is shown in table 39.

Period	Find spots
Mesolithic	1
Neolithic	19
Bronze Age	29
Iron Age	7
Romano-British	175
Total	231

Table 39. Breakdown of Portable Antiquities Scheme finds by period.

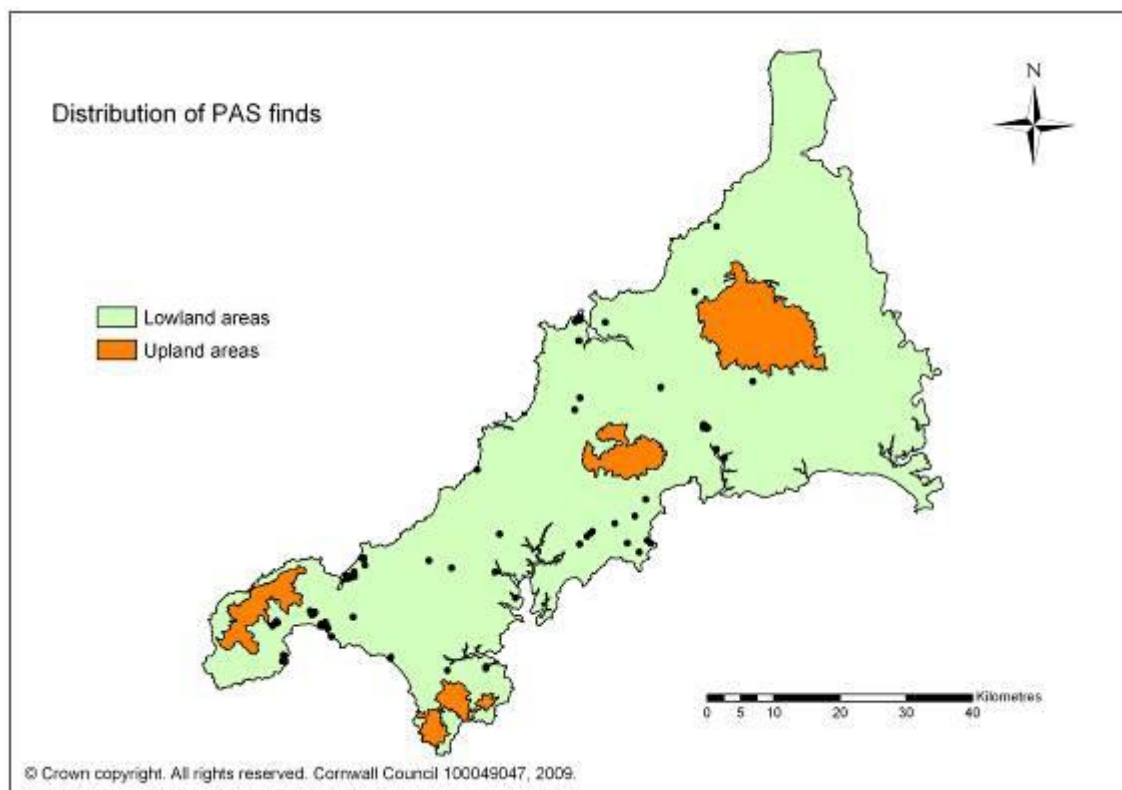


Fig 43. Distribution of all find spots recorded by the Portable Antiquities Scheme (PAS) in the Lowland Cornwall project area

The high level model for PAS finds is set out in table 40.

PAS find spots: high probability zone				
HLC Type	Sites	PA	PS	Cum. Kj
Farmland Prehistoric	37	0.0275	0.1602	0.1458
Farmland Post Medieval	50	0.1599	0.2165	0.2669
Farmland Medieval	105	0.5215	0.4545	0.3187
Dunes	16	0.0027	0.0693	0.4123
Ancient Woodland	5	0.0223	0.0216	0.4165
Coastal Rough Ground	4	0.0151	0.0173	0.4228
Upland Rough Ground	4	0.0284	0.0173	0.1458
Total	221	0.7774	0.9567	
PAS find spots: medium probability zone				
HLC Type	Sites	PA	PS	Cum. Kj
Farmland C20	6	0.1076	0.0260	0.4141
Communications	1	0.0042	0.0043	0.3098
Water: Natural	1	0.0059	0.0043	0.3108
Ornamental	1	0.0137	0.0043	0.3090
Settlement C20	1	0.0309	0.0043	0.2941
Total	10	0.1623	0.0432	

Table 40. High level model for PAS find spots reduced to a single point per site.

No PAS finds are recorded from any other HLC Type. These Types consequently make up the low probability zone.

Model performance is summarised in the table below.

Potential	PA	PS	Kvamme's gain	PS/PA
High	0.7774	0.9567	0.1874	1.23
Medium	0.1076	0.0260	-3.1419	0.24
Low	0.1150	0.0173	-5.6405	0.15

This model is very accurate in that 95% of the sites are captured in the high probability zone. This zone, however, produces a poor Kvamme's gain, given that it covers as much as 77% of the project area, and overall the model is not at all precise. Nonetheless the ratio of Indicative Values (PS/PA) indicates that the chances of encountering a site in the high probability zone are five times greater than in the medium probability zone and eight times greater than in the low probability zone. The chances of encountering a site in the medium probability zone are 1.6 times higher than in the low probability zone.

Although the high ranking for Farmland Prehistoric and Coastal Rough Ground is consistent with all the other finds models, the pattern for PAS data differs significantly in other respects. Farmland Medieval is ranked third whereas it is ranked much lower in all the other models, Upland Rough Ground is ranked in the medium probability zone rather than the high probability zone (unlike all the other models) and both Farmland C20 and Settlement C20 are included in the low probability zone whereas in all the other models they are ranked much higher.

The probability map produced by this model is shown in Fig 44.

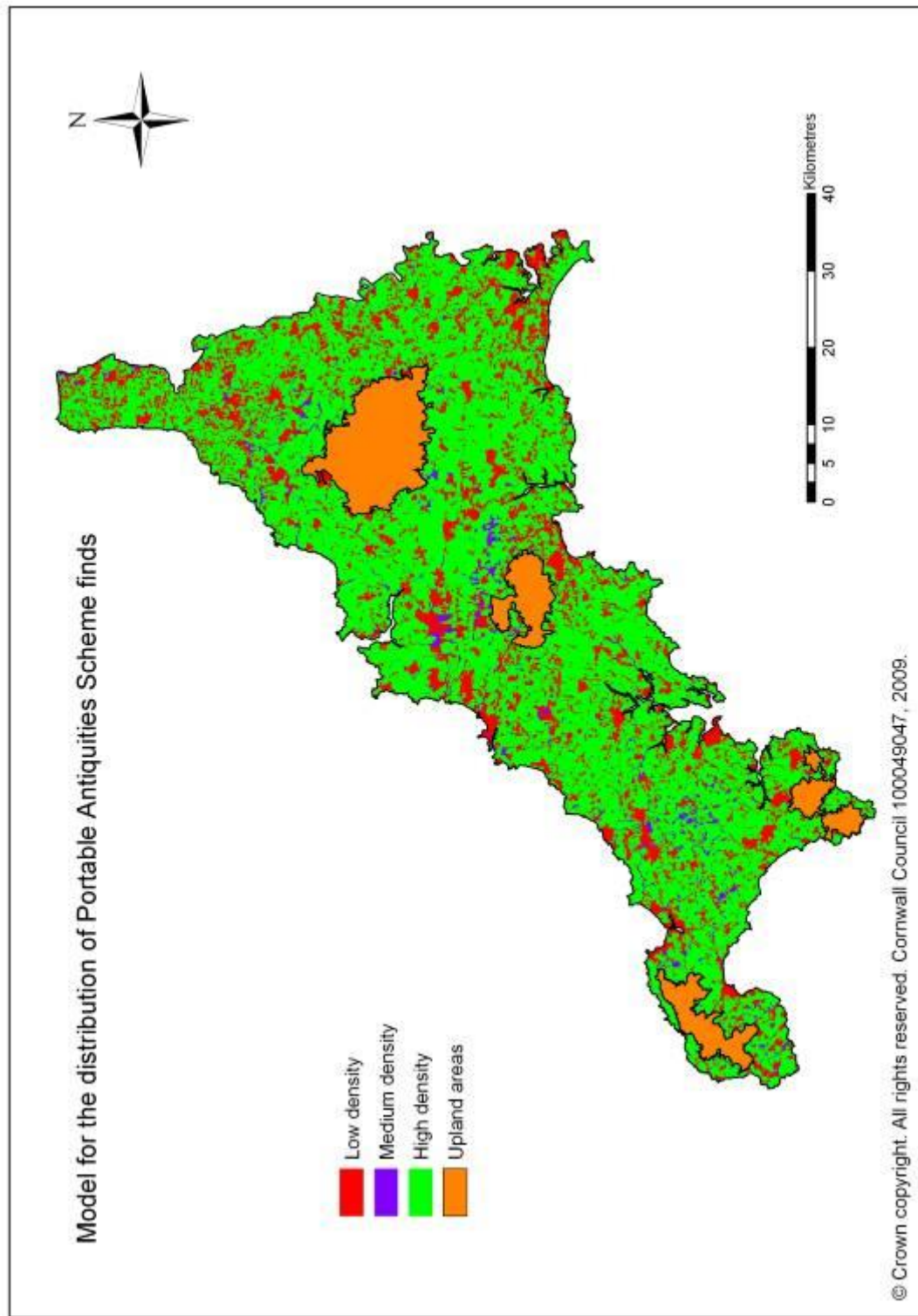


Fig 44. Probability map based on the high level HLC model for Portable Antiquities Scheme finds in Lowland Cornwall.

8.6.8 Conclusions

- It was not possible to clearly define a medium probability zone in the models for Mesolithic, Neolithic or Bronze Age find spots, nor in the model for all prehistoric and Romano-British find spots. Consequently two-zone models were built for these site types, comprising high and low probability zones only.
- Apart from the model for Iron Age and Romano-British find spots, the models are all reasonably accurate to very accurate, with high probability zone capture rates ranging from 63% (generic prehistoric finds) to 90% (Mesolithic finds) and 96% (PAS finds).
- Apart from the Neolithic and PAS finds models, all the models are precise, with the high probability zone covering less than 40% of the project area in all. The models therefore produce relatively high Kvamme's gain values, with all being in excess of 0.40. The Neolithic finds model is reasonably precise but the PAS model is not at all precise.
- The Mesolithic finds model performs best, with a high probability zone covering only 38% of the project area but capturing 90% of the find spots. This model produced a Kvamme's gain value of 0.5784.
- Although the Iron Age and Romano-British finds model is not very accurate (only 56% of sites are captured in the high probability zone) this is the most precise model – the high probability zone only covering 24% of the project area.
- In terms of where prehistoric and Romano-British find spots are most likely to be encountered, the HLC Type Farmland Prehistoric is by far the most important Type. It is ranked highest in all seven 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.
- Other important HLC Types, in descending order are: Coastal Rough Ground, Farmland Post medieval, Farmland C20, Settlement C20 and Upland Rough Ground. These are all in the five top ranked Types in five or more of the models. The HLC Types Dunes and Settlement older core are also of some importance, being included in the high probability zone of five or more of the models.
- A curiosity of the models is the inclusion in the high probability zone of the Mesolithic, Neolithic and Iron Age and Romano-British models of the HLC Type Water: Natural. The finds from these Types are all from beaches or cliff faces (at Trebetherick Point, Trevedra, Widemouth Bay, Winnianton and Praa Sands) and hint at slight inaccuracies in defining of the 1994 HLC polygons. It might be more satisfactory to regard these finds as coming from Coastal 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 has taken place here than in the other Types. But the results suggest either this is not the case or that, if it is, relatively few finds have been made.
- If Farmland Medieval has been intensively walked, its poor performance is reason to question the premise that Anciently Enclosed land, embodied over most of Lowland Cornwall by this HLC Type, was the zone of settlement and farming as early as the Bronze Age. It is difficult to explain why proportionately more artefacts have been found in areas of Rough Ground and

former Rough Ground, which would have been remote from the areas of settlement and farming, than have been found in the settlement zone itself.

- A significant weakness of the dataset, which may explain the poor performance of the HLC Type Farmland Medieval, is that there has been no systematic programme of field walking in Cornwall. Because of this 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. And within those areas where finds collection has taken place, factors such as access to land will have further skewed the picture. This is obviously the case with PAS finds, which have been made during a series of repeat visits to only 54 individual locations.
- A significant weakness of the dataset (and 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.
- The single salient factor arising from these models is the importance of the HLC Type Farmland Prehistoric.
- The secondary conclusion to be drawn from the find spot models is that whilst they underline the importance of Rough Ground and former Rough Ground in the prehistoric landscape, they are 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.

9 Testing the models using Events Record data

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 recorded in the HER and therefore provided a useful independent data sample with which to test the high level models developed during the project. Coherent and informative site plans resulting from events were digitised and added to the GIS so that they could be analysed in more detail during the second phase of the project. Medieval and early medieval material recorded during the events was also analysed to compare the distribution pattern with that of earlier periods.

9.1 Methodology

9.1.1 Data refinement

At the time of the analysis (July 2009), the Cornwall and Isles of Scilly Events Record contained details of 3,694 individual interventions. The dataset was filtered to include only those types of 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.

The filtered dataset comprised 1,336 Events. This was refined further by removing Events considered to have little potential. These included *shaft-capping works* and *building surveys* involving watching briefs which had not been filtered out in the initial refinement, Events in urban contexts known to have recorded no relevant material, and minor interventions such as the series of watching briefs at Pendennis Castle. The revised dataset was then clipped in GIS to the Lowland Cornwall polygon. As a result of the refinement process the Events dataset analysed during the project contained details of 750 individual interventions.

As the analysis preceded 326 more Events were filtered out of the dataset for the following reasons.

- They were extensively disturbed by post medieval or later activity.
- Archaeological levels were not fully observed (i.e. topsoil not fully stripped along a pipeline, or use of a toothed machine bucket etc.).
- Areas were extensively disturbed by mining activity.
- An event produced negative results but later work in the same area proved that archaeology was present.
- Geophysical survey results were extensively disturbed by ferrous or other signals.
- Minor Events within a known monument produced negative results (actual examples; a small trench within a hillfort, minor works in a churchyard).

9.1.2 Categorisation of Events

The remaining 424 events comprised the following event types.

Excavation (including test pits and trial 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 is that although an Event may examine only a portion of a field (for instance a single trench in a field) 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 polygon created as described above had a series of attributes attached to it.

- **Category:** (1-5, see below)
- **Site type(s):** (Settlement, ditch, pit etc.)
- **Period(s):** (PX, PA, ME, NE, BA, IA, RB, EM, MD or Unknown)
- **Event:** (the Event UID No. to identify the Event's report and the type of Event (excavation, watching brief etc).
- **Comments:** (where appropriate)
- **ID:** (Sites already recorded in the HER were ascribed the ID value 10; those not already recorded were ascribed the value 0)
- **Area:** (The size of the polygon in square metres was automatically generated)

The categories were designed to distinguish at a general level between the types of the recorded remains, and 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 sites (Fig 45).

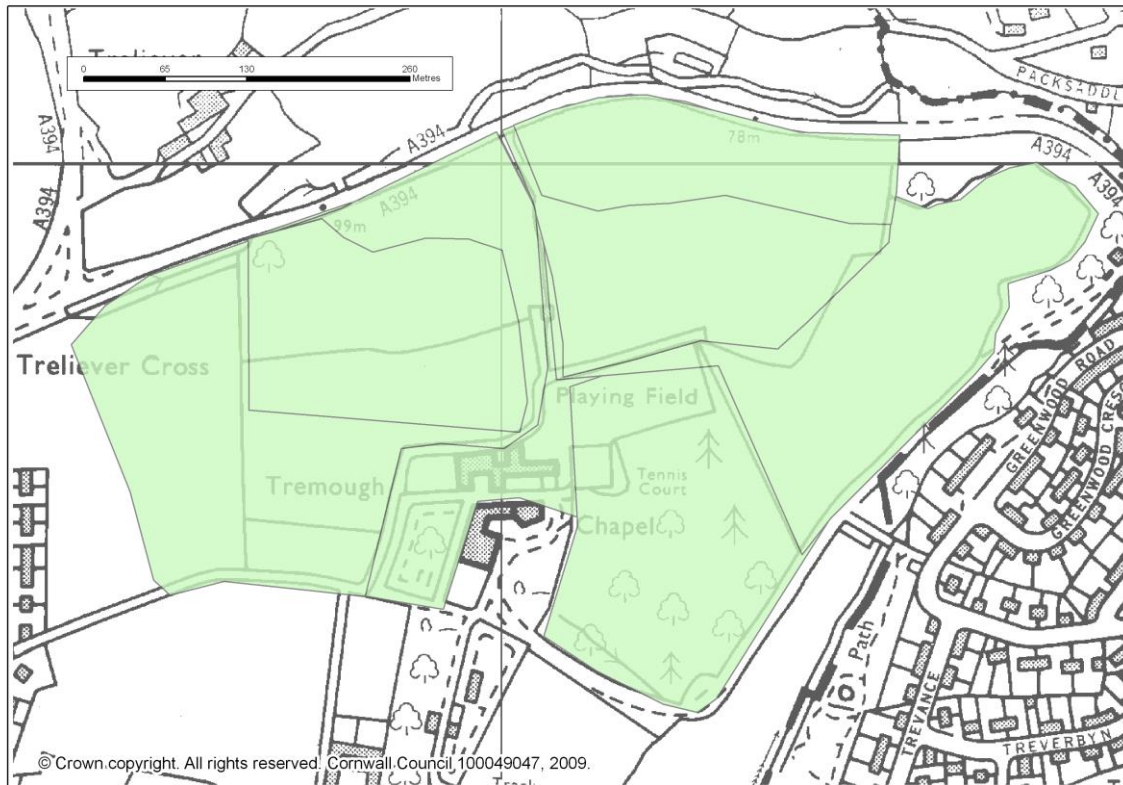


Fig 45. A series of overlapping polygons defining numerous events carried out at Tremough, Penryn.

The polygons defining these events overlap and overlay each other and this makes it difficult to calculate the extent of the site. The sum of the area covered by all nine polygons in the case of Tremough is 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 and whose sum comes to 26ha. After this final filtering process the events test dataset contains 694 polygons and covers a total area of 54.36km² (Fig 46).

As can be seen from the table 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).

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

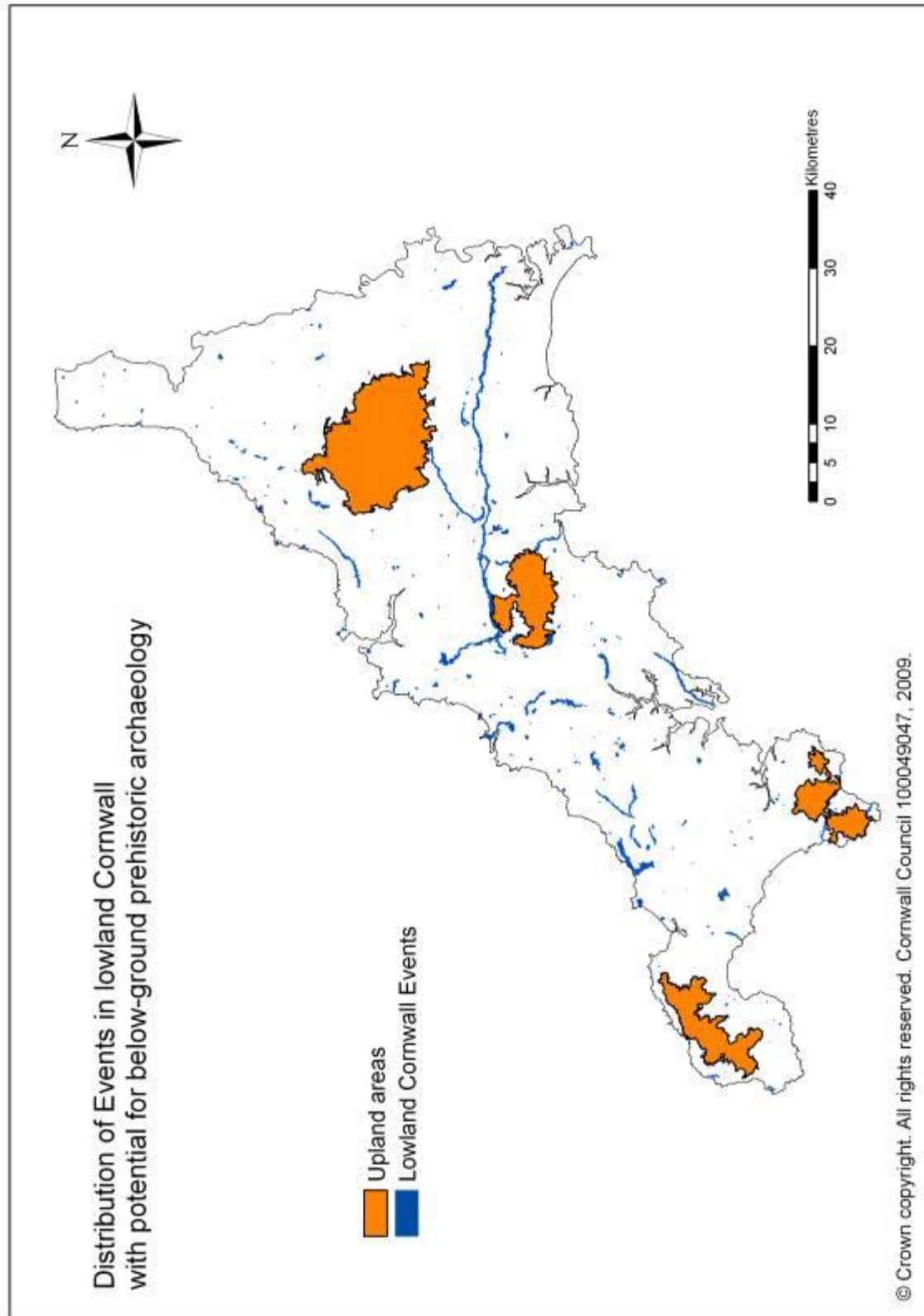


Fig 46. Distribution of Events with potential for below-ground prehistoric and Romano-British archaeology in Lowland Cornwall.

9.2 Analysis of the Events and model testing

A spatial union was performed in GIS linking the lowland Event polygons with HLC Types. In many cases the Events polygons intersect more than one HLC Type; in total the Events/HLC layer comprises 1,248 individual polygons, covering a total surveyed area of 54.36km². Centroid points were created for each of the polygons so that the data can be analysed by numbers of sites (points) or by site area (polygons). The layer can 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 the table below.

Site type	No of features	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 41. 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 HER. This means that the remaining 967 Events polygons can be used as an independent set of data with which to test the HLC 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 must be taken into account. For instance, whereas Farmland Post Medieval forms 15.99% of the Lowland Cornwall project area it forms 28.07% of the area surveyed by the Events. Farmland Prehistoric, on the other hand, covers 2.75% of Lowland Cornwall but only 0.35% of the Events area.

The simplest way to compensate for this variance is to calculate the S/A value - the number of sites per km² - for each of the model's probability zones. The area (in km²) making up each zone in the test survey area is 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 can be defined. This is illustrated below using the rounds and enclosures model as an example; the S/A values are calculated from the model as follows:

Probability	AREA	SITES	S/A
High	2094.5	1551	0.74
Medium	558.36	268	0.48
Low	537.02	138	0.26
Total	3189.88	1957	0.61

So, for the high probability zone in the test sample area the expected density of sites is 0.74 per km² and, given that this zone covers 31.96km², we can predict the theoretical number of sites to be captured in this zone is 31.96 x 0.74 = 23.65. In total we can expect, in theory, 33.23 sites to be recorded in the test sample and the proportion of

these falling within the high probability zone will be $23.65/33.23 = 0.71$ or 71% (table 42 below).

Zone	Area km ²	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 42. Method for Calculating the predicted PS (proportion of sites) for each probability zone of the rounds and enclosures model using the Events as a test sample.

9.3 Test results

9.3.1 The rounds and enclosures model

In the lowland events dataset 76 sites were interpreted as rounds or enclosures indicative of settlement evidence. 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 geophysical surveys interpreted as likely to be prehistoric). Evidence of Neolithic activity was recorded at one of the enclosures and Bronze Age activity at 13 of the later enclosures. Early medieval material was recorded at seven and medieval material at five of the sites.

Forty three of the enclosures are already recorded in the HER and 33 are new sites. This data was used as a sample to test the rounds/enclosures HLC model in two ways. Firstly the whole dataset was used (as a largely internal test sample) and then the new sites 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 the area taken up by the sites as well as by site density.

Testing with all 76 sites

Zone	Area km ²	SA	NS	Predicted PS	PS	Predicted Sites	Sites
High probability	31.96	0.74	23.65	0.71	0.68	54	52
Medium probability	17.05	0.48	8.18	0.25	0.22	19	17
Low probability	5.35	0.26	1.39	0.04	0.09	3	7
Totals	54.36	0.61	33.23	1.00		76	76

Table 43. Results of events record testing of the rounds and enclosures model: test based on numbers of sites. NS = notional number of sites predicted.

Zone	Area km ²	Predicted PS	PS	Predicted site area	Site area
High probability	31.96	0.71	0.72	295.39	300.31
Medium probability	17.05	0.25	0.25	102.93	103.16
Low probability	5.35	0.04	0.03	15.93	10.78
Totals	54.36			414.25	414.25

Table 44. Results of events record testing of the rounds and enclosures model: test based on site area.

The result of the test based on number of sites is a close fit, with the proportion of sites in both the high and medium zones accurately predicted (within 3%). The main element of inaccuracy is the significantly better than predicted performance of the low probability zone. There are two possible underlying causes of this inaccuracy. 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 HER 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 is even better. The inaccuracies relating to the low probability zone have vanished and the high probability zone is performing 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 HER and therefore were part of the dataset used to formulate the original model (these sites do, however, constitute a useful 'internal' test sample). The tables below show the results of testing the model using only the previously unrecorded sites.

Testing with the 33 new sites

Zone	Area km ²	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 45. Results of events record testing of the rounds and enclosures model: test based on numbers of sites. NS = notional number of sites predicted.

Zone	Area km ²	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 46. Results of events record testing of the rounds and enclosures model: test based on site area.

The test based on number of sites fits perfectly with the rounds and 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) but the number of predicted sites has been rounded up from 23.65 to 24. One would naturally expect the independent sample to perform worse than that containing previously recorded sites which contributed to the building of the original model. The fact that this is not the case serves as an indication that the model is probably not uniform across the whole project area and that some areas – particularly in the low probability zone – are more densely populated with sites than others.

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 better (whether the test is based on point data or site area) when tested with the new sites. 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 objective but on the strength of this testing, it can be concluded that the rounds/enclosures HLC model is largely accurate.

9.3.2 The open settlements model

Seventy three settlements which can be regarded as unenclosed are recorded in the Events record. These range from single round houses to quite extensive groups of houses and other structures accompanied by pits, ditches and post holes. Frequently these settlements are located adjacent to, or in the vicinity of, rounds and enclosures. For sites where no excavation has taken place (especially those where the evidence is based solely on geophysical survey anomalies) the interpretation of features as open settlements is somewhat subjective, and the dataset should be regarded as indicating those sites which are definitely, probably or possibly open settlements.

One site is 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. Evidence of Mesolithic activity was recorded at three of the later settlements, Neolithic activity at four and Bronze Age activity at nine of the settlements. Early medieval material was found at five sites and medieval material at eight. In total 29 of the settlements can be regarded as multi-period sites.

Testing with all 73 sites

In relation to the high level models these sites have been used to test the hut circle and round house HLC model. Tests were carried out on the basis of point data and site area, with the full dataset, and with only new sites (which number 40 in total). The table below shows the full Events dataset for open settlements used to test the hut circles HLC model based on one point per site.

Zone	Area km ²	SA	NS	Predicted PS	PS	Predicted Sites	Sites
High probability	25.23	0.173	4.31	0.82	0.40	60	29
Medium probability	27.50	0.034	0.94	0.18	0.52	13	38
Low probability	1.63	0.013	0.03	0.00	0.08	0	6
Totals	54.36		5.27			73	73

Table 45. Results of events record testing of open settlements model: test based on numbers of sites. NS = notional number of sites predicted.

Zone	Area km ²	Predicted PS	PS	Predicted site area	Site area
High probability	25.23	0.82	0.38	349.31	161.58
Medium probability	27.50	0.18	0.60	75.73	254.38
Low probability	1.63	0.00	0.03	2.03	11.12
Totals	54.36			427.08	427.08

Table 46. Results of events record testing of the open settlements model: test based on site area.

When tested by Events point data the model is clearly rejected by the test sample, with only half the number of sites as predicted captured in the high probability zone. The medium probability zone performs almost three times better than expected (capturing 52% of the sites rather than the 18% predicted) and captures the majority of the sites. Although the low probability zone only captures a few sites, its performance is also significantly better than predicted. When the test is based on site area the enhanced performance of the medium probability zone at the expense of the high probability zone is even plainer, with 60% of the sites captured in the former.

Testing with the 40 new sites

When the tests are run using only the 40 newly identified sites from the Events dataset the performance of the model is even worse (tables 47 and 48).

Zone	Area km ²	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 47. 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 km ²	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 48. Results of events record testing of the open settlements model: test based on site area for previously unrecorded sites.

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 the area taken up by these sites.

Analysis of the Events data suggests that the cause of gross error in the open settlements HLC model is the high proportion of sites recorded from the HLC Type Farmland Medieval in the test sample. In fact the distribution of new sites listed in the Events Record has much in common with the rounds and enclosures HLC model (table 49).

HLC Type	Area ha	Zone	Sites	PA	PS
Coastal Rough Ground	73.28	Medium	2	0.013	0.050
Farmland C20	525.25	High	1	0.093	0.025
Farmland Medieval	2651.17	High	25	0.503	0.625
Farmland Post Medieval	1525.95	Medium	7	0.277	0.175
Ornamental	44.09	Low	2	0.010	0.050
Settlement C20	54.80	Low	3	0.013	0.075
Other	561.19	Various	0	0.091	0
Total	5435.73		40		

Table 49. HLC Types containing new open settlements in the Events Record dataset compared with the probability zones of the rounds and enclosures model.

Testing against the rounds and enclosures model

This table shows that 26 of the 40 sites (65%) are captured within the high probability zone of the rounds and enclosures model, nine in the medium probability zone and 5 in the low probability zone. For this reason the Events Record sample was tested against the rounds and enclosures model. For this test the open settlements were treated as if they were rounds or enclosures and therefore the sites per km² values used to calculate the predicted number of sites and predicted PS were those of the rounds and 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 results of this test are shown in tables 50 and 51.

Zone	Area km ²	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 50. Results of events record testing the distribution of open settlements against the rounds and enclosures model: test based on numbers of previously unrecorded sites. NS = notional number of sites predicted.

Zone	Area km ²	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 51. Results of events record testing the distribution of open settlements against the rounds and 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 enhanced at the expense of the high probability zone. However, 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 rounds and enclosures (table 46), 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 potentially significant. The model for the distribution of open settlements based on the HER dataset correlated with HLC was rejected by the test. Further testing demonstrated that the distribution of open settlements identified from Events conforms strongly to the model for rounds and 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 rounds and enclosures – most notably the HLC Type Farmland Medieval – and the rounds and enclosures model serves as a more accurate indicator of those areas where undiscovered open settlements are most likely to be located in the future.

9.3.3 The field systems model

Twenty eight field systems are recorded in the Events record. When set against the number of enclosures (76) and open settlements (73) this figure seems surprisingly small. Given the keyhole nature of many of the Events, however, it is quite possible that linear features recorded during geophysical surveys and minor excavations are

fragments of field systems but could not be confidently interpreted as such due to the limited evidence available.

One field system 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. Mesolithic material was found at one site and Neolithic material at three. Evidence of Early medieval activity was recorded at four sites and medieval activity at six. Eight of the field systems are potentially multi-phased. Eighteen of the field systems are new sites whilst ten were previously recorded in the HER.

Testing of the field systems/HLC model was carried out using both the complete Events dataset and then using only the new sites. Each test was run twice; firstly using point data and secondly using polygons created for each site as a measure of site area (the polygon outlines were defined by field boundaries shown on current OS mapping). A measure of how far these tests validate the model is presented in the tables below.

Testing with all 28 sites

Zone	Area km ²	SA	NS	Predicted PS	PS	Predicted Sites	Sites
High probability	34.70	0.21	7.29	0.83	0.75	23	21
Medium probability	16.42	0.09	1.48	0.17	0.18	5	5
Low probability	3.24	0.02	0.06	0.01	0.07	0	2
Totals	54.36		8.83			28	28

Table 52. Results of events record testing of the field systems model: test based on numbers of sites. NS = notional number of sites predicted.

Zone	Area km ²	Predicted PS	PS	Predicted site area	Site area
High probability	34.70	0.83	0.64	128.97	99.63
Medium probability	16.42	0.17	0.35	26.16	54.27
Low probability	3.24	0.01	0.02	1.15	2.38
Totals	54.36			156.27	156.27

Table 53. Results of events record testing of the field systems model: test based on site area.

The test data fits the model well using point data (table 52), although as in some of the other tests (e.g. the rounds/enclosures and open settlement tests) the low probability zone performs better than predicted at the expense of the high probability zone. The medium probability zone performs very much as predicted.

When tested using site area as the measure of PS, the model performs poorly (table 53). One reason for this is that field systems can cover extensive areas and in some cases their polygon extends over two or more HLC Types. Although 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 16 field systems centred on Farmland Medieval cover 88.86 ha of that HLC Type – an average of 5.55 ha per site).

A second, more explicit cause of the relatively high site area in the medium probability zone is the large area formed by field systems in the HLC Type Dunes – most notably the field systems at Gwithian (the polygon for Gwithian is 13 ha in extent).

As a result the performance of the medium probability zone for field systems is enhanced when quantified on the basis of site area, at the expense of the high probability zone. The low probability zone performs a little better than expected.

Testing with the 18 new sites

In both cases (when using either point data or site area) testing with only the new sites produces a slightly better fit for the high probability zone but varying results for the medium and low probability zones.

Zone	Area km ²	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 54. Results of events record testing of the field systems model: test based on numbers of new sites. NS = notional number of sites predicted.

Zone	Area km ²	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 55. Results of events record testing of the field systems model: test based on site area for the 18 new sites.

In conclusion the distribution of field systems identified in the events record fits fairly well with the field systems HLC model, although the test suggests that the likelihood of finding field systems in the medium probability zone is understated in the original model. This is more pronounced when measuring the model by site area rather than point data and applies to the previously unrecorded sites as well as the complete dataset. The biggest discrepancy in this regard concerns the previously unrecorded sites; whilst only 11% of sites are captured in the medium probability zone when tested using point data, this figure rises to 28% when the test is based on site area. As mentioned above this is partly caused by field systems centred on the high probability zone extending into parts of the medium probability zone, and partly by differences in polygon size between the various probability zones (see section 9.4 for further discussion). When evaluating the performance of the high probability zone in these tests it should be borne in mind that only a tiny portion of the HLC Type Farmland Prehistoric has been surveyed by the Events (see section 9.4, table 63) and this is the highest ranked Type in the field systems model.

9.3.4 The Bronze Age barrows model

Fifty five barrows are recorded in the Events record. This figure includes sites listed as barrow, barrow cemetery, cairn, burial and cist where the period is interpreted as Bronze Age. Mesolithic material was recorded at two of the sites, Neolithic material at seven, Iron Age at two, Iron Age/Romano-British finds at one and medieval material at two of the barrows. Only 11 of the barrows are new sites.

Even though 11 new sites is a very small sample, testing of the model was carried out using both the complete dataset and then using only the new sites. Each test was run twice; firstly using point data and secondly using polygons created for each site as a measure of site area (the polygon outlines were defined by field boundaries shown on current OS mapping). A measure of how far these tests validate the model is presented in the tables below.

Testing with all 55 sites

Zone	Area km ²	SA	NS	Predicted PS	PS	Predicted Sites	Sites
High probability	24.75	1.1	27.23	0.69	0.76	38	42
Medium probability	26.93	0.43	11.58	0.29	0.20	16	11
Low probability	2.68	0.3	0.80	0.02	0.04	1	2
Totals	54.36		39.61			55	55

Table 56. Results of events record testing of the barrows model: test based on numbers of sites. NS = notional number of sites predicted.

Zone	Area km ²	Predicted PS	PS	Predicted site area	Site area
High probability	24.75	0.69	0.82	179.50	214.76
Medium probability	26.93	0.29	0.18	76.35	45.76
Low probability	2.68	0.02	0.00	5.30	0.63
Totals	54.36			261.15	261.15

Table 57. Results of events record testing of the barrows model: test based on site area.

Clearly the Events record data for barrows is a very close fit to the barrows HLC model. The main difference is that the high probability zone performs better than predicted at the expense of the medium probability zone. This discrepancy is slightly more marked when the test is based on site area rather than point data. In the site area test (see the table below) the low probability zone also performs worse than predicted. In the context of predictive models, the fact that the high probability zone is performing better than expected is not in itself a bad result, and overall the model is strongly validated by the tests. This, of course, is to be expected as so many of the barrows in the dataset are recorded in the HER and therefore were part of the dataset used to formulate the original model (these sites do, however, constitute a useful 'internal' test sample).

Testing using the 11 new sites

When the model is tested by the new sites identified in the Events record a very different result is obtained. 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. The test results are set out below, firstly based on one point per site and then based on area.

Zone	Area km ²	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 58. Results of events record testing of the barrows model: test based on numbers of new sites. NS = notional number of sites predicted.

Zone	Area km ²	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 59. Results of events record testing of the barrows model: test based on site area for the 11 new sites.

When the test is based on point data there is an equal proportion of sites in the high and medium probability zones and a better-than-predicted performance from the low probability zone.

The test based on site area confirms the result of the point data test in that the model is rejected. Using site area as the measure of PS, the performance of the medium probability zone is enhanced at the expense of both high and low zones. In this test the medium probability zone actually scores higher than the high zone.

Using only the 11 newly recorded barrows as the test sample it is clear that the test rejects the model, with the medium probability zone performing far better than expected at the expense of the high probability zone. Bearing in mind that the original barrows HLC model largely reflects the distribution of sites with extant remains, a case can be made for suggesting that the model is based on incomplete information and that more plough-levelled barrows remain to be discovered in the medium probability zone – most notably within the HLC Type Farmland Medieval, which forms the bulk of this zone. However the results must be regarded as inconclusive at present due to the very limited size of the new site dataset.

9.3.5 The Prehistoric and Romano-British find spots model

In total prehistoric and/or Romano-British finds were recorded at 189 locations in the Events record dataset. These were used to test the two zone find spots model (section 8.6.1). Each test was run twice; firstly using point data and secondly using polygons created for each site as a measure of site area (the polygon outlines were defined by field boundaries shown on current OS mapping). A measure of how far these tests validate the model is presented in the tables below.

Zone	Area km ²	SA	NS	Predicted PS	PS	Predicted Sites	Sites
High probability	25.60	1.01	25.86	0.74	0.30	139	57
Low probability	28.76	0.32	9.20	0.26	0.70	50	132
Totals	54.36		35.06			189	189

Table 60. Results of events record testing of the find spots model: test based on numbers of sites. NS = notional number of sites predicted.

Zone	Area km ²	Predicted PS	PS	Predicted site area	Site area
High probability	25.60	0.74	0.30	440.99	179.22
Low probability	28.76	0.26	0.70	156.97	418.73
Totals	54.36			597.96	597.96

Table 61. Results of events record testing of the find spots model: test based on site area.

Predictions based on the original model indicate that 74% of the finds should come from the high probability zone whereas the actual percentage is 30% regardless of

whether the analysis is based on point data or on site area. In both cases the majority of the finds were made in the low probability zone. For all the HLC Types constituting the low probability zone where finds were recorded (apart from Communications) the proportion of sites is greater than the proportion of area. In contrast, for the HLC Types Farmland Post Medieval and Coastal Rough Ground (in the high probability zone) the proportion of area is substantially greater than the proportion of sites.

Find spots model. High probability zone				
HLC Type	Area (ha)	Finds	PA	PS
Coastal Rough Ground	73.28	1	0.013	0.005
Dunes	60.76	0	0.011	0
Farmland C20	525.25	18	0.093	0.095
Farmland Post Medieval	1525.95	27	0.277	0.143
Farmland Prehistoric	19.14	3	0.003	0.016
Recreational	75.23	2	0.013	0.011
Settlement C20	54.80	1	0.009	0.005
Settlement older core (pre- 1907)	10.82	5	0.002	0.026
Upland Rough Ground	201.54	0	0.035	0
Water: Natural	12.70	0	0.002	0
Total	2559.47	57	0.458	0.301

Find spots model. Low probability zone				
HLC Type	Area (ha)	Finds	PA	PS
Ancient Woodland	22.88	1	0.004	0.005
Communications	35.38	1	0.007	0.005
Farmland Medieval	2651.17	126	0.488	0.667
Industrial: Disused	25.55	0	0.005	0.000
Industrial: Working	9.86	1	0.002	0.005
Military	41.79	0	0.008	0.000
Ornamental	44.09	3	0.008	0.016
Plantation and Scrub	45.44	0	0.008	0.000
Water: Reservoirs	0.10	0	0	0
Total	2876.26	132	0.53	0.698

Table 62. Results of events record testing of the find spots model: number of finds from each HLC Type.

On the strength of this independent test there are strong indications that the model should be rejected. However it was not possible to construct an alternative model based on Events record data because a Chi-Squared test on the events data did not reject the null hypothesis, indicating that the pattern of finds derived from the events data could result from a by chance distribution.

In conclusion whilst the sample derived from the events record is probably too small to produce a revised model with which we can confidently replace the HER-based model, it does demonstrate that the HER-based model for prehistoric finds cannot be regarded as reliable. It is reasonable to suggest from this evidence that the pattern of finds distribution presented by the HER derives from a biased sample and that further finds

retrieval in lowland Cornwall would provide a great deal more evidence from HLC Types such as Farmland Medieval which appear to be currently under-represented in the HER.

Models were made for finds from each period (sections 8.6.2 – 8.6.6) and all are broadly similar (in some cases very similar) to the overall prehistoric and Romano-British finds model tested here. Therefore these individual period-based models were not tested because it is obvious that the results would be the same as those presented above and each of the models would be rejected by the Events test sample.

9.4 Weaknesses of the Events record data

9.4.1 The sample is not representative

The lowland Events dataset can be regarded as 'compliance' survey data – surveys carried out because there is a legal obligation to do so – and there are inherent weaknesses when using data of this sort for model testing (Verhagen 2007, 145-149).

Firstly it is widely accepted that probabilistic sampling (sampling aimed at obtaining a statistically valid sample) is the ideal method for collecting test data sets for predictive models (Orton 2000). Compliance surveys are not probabilistic in that their aim is the discovery of all (or at least a proportion of) the archaeological sites in a predetermined area, and as a result are not usually representative (Verhagen *ibid*). This appears to be the case in this instance.

Based on the approach described in section 9.1.2 (representing the events as polygons defined by present day field boundaries) the lowland Events cover a total area of 5,435.73 ha. A breakdown of the area of events within each HLC Type is shown in the table below. This table also shows the area extent of each HLC Type in the Lowland Cornwall project area for comparison, and the area proportion of each HLC Type where Events have taken place (expressed as a percentage). Area is measured in hectares.

HLC Type	Lowland Cornwall	Events polygons	% of Type
Ancient Woodland	7117.35	22.8801	0.32
Coastal Rough Ground	4820.20	73.2777	1.52
Communications	1324.77	35.3778	2.67
Dunes	860.51	60.7591	7.06
Farmland C20	34317.20	525.2483	1.53
Farmland Medieval	166363.86	2651.1669	1.59
Farmland Post medieval	51015.69	1525.9506	2.99
Farmland Prehistoric	8764.97	19.1372	0.22
Industrial: Disused	1143.62	25.5526	2.23
Industrial: Working	501.47	9.8565	1.97
Military	1765.06	41.7866	2.37
Ornamental	4378.70	44.0900	1.01
Plantation and Scrub	11536.67	45.4401	0.39
Recreational	1985.40	75.2318	3.79
Rough Ground/Industrial	368.81	0	0.00
Settlement C20	9846.44	54.8043	0.56
Settlement older core	1664.77	10.8221	0.65
Upland Rough Ground	9044.59	201.5403	2.23

Water: Natural	1875.52	12.7021	0.68
Water: Reservoirs	287.83	0.1038	0.04
Total	318,983.43	5,435.73	1.70

Table 63. The extent of each HLC Type surveyed by interventions recorded in the Events Record.

It can be concluded that the lowland Events dataset does not constitute an ideal test sample. Firstly it is rather small, covering less than 2% of the overall project area; secondly it is not particularly representative of the project area. The proportion of Events within no HLC Type is consistent with the proportion of Events in Lowland Cornwall as a whole (1.70%): for instance the events polygons take up 1.59% of the total area covered by the HLC Type Farmland Medieval whereas the total area covered by the events makes up 1.7% of the Lowland Cornwall project area. Most significantly, Farmland Prehistoric is under-represented in the events record (only 0.22% of events) and Farmland Post Medieval is over-represented (2.99%).

Differences between the test sample (the Events polygons) and the model (the project area) can be measured by comparing the area proportions of each HLC Type in the two datasets. This is shown in the table below. The area percentage of Lowland Cornwall taken up by each HLC Type is shown in the second column; the area percentage of the lowland Events in the third column, and the proportionate difference for each HLC Type in the final column. Proportionate difference is calculated by dividing the area percentages for the Events polygons by the area percentages for Lowland Cornwall. The HLC Types are arranged according to the measure of proportionate difference in descending order.

HLC Type	Lowland Cornwall	Events polygons	Difference
Dunes	0.27	1.12	4.14
Recreational	0.62	1.38	2.22
Farmland Post Medieval	15.99	28.07	1.76
Communications	0.42	0.65	1.57
Military	0.55	0.77	1.39
Industrial: Disused	0.36	0.47	1.31
Upland Rough Ground	2.84	3.71	1.31
Industrial: Working	0.16	0.18	1.15
Farmland Medieval	52.15	48.77	0.94
Farmland C20	10.76	9.66	0.90
Coastal Rough Ground	1.51	1.35	0.89
Ornamental	1.37	0.81	0.59
Water: Natural	0.59	0.23	0.40
Settlement older core (pre- 1907)	0.52	0.20	0.38
Settlement C20	3.09	1.01	0.33
Plantation and Scrub	3.62	0.84	0.23
Ancient Woodland	2.23	0.42	0.19
Farmland Prehistoric	2.75	0.35	0.13
Water: Reservoirs	0.09	0.002	0.02

Table 64. Comparison of the proportion of the Lowland Cornwall project area taken up by each HLC Type with the proportion of each HLC Type surveyed by interventions recorded in the Events Record.

The proportionate differences for HLC Types Farmland Medieval and Farmland C20 show that the area of these types covered by the Events polygons closely reflects the proportion of Lowland Cornwall taken up by them (if the area proportions corresponded perfectly the proportionate difference would be 1). In contrast the area of Dunes covered by the Events polygons is more than four times greater than the proportion of Lowland Cornwall made up by this Type. Therefore it is likely that when using the lowland Events layer as a test sample, even when the proportionate differences are weighted (as outlined in section 9.2 above), the importance of those HLC Types towards the top of the table will be overstated and those towards the bottom will be understated.

9.4.2 Inconsistencies within the dataset

Another area of weakness arises because the Events Record consists of numerous survey projects. These have been carried out over a considerable period by a range of organisations, and inevitably the quality of the data is inconsistent. Particular issues encountered in analysing the events data were:

- Not all survey reports produced by external organisations were easily accessible.
- Older reports sometimes did not include overall site plans (despite containing numerous section drawings).
- For some of the more complex Events, precise locations of minor features and find spots could not be ascertained without consulting the relevant archives and project resources did not allow time for this.
- The detail of location maps accompanying Event reports varied considerably: in some cases it was not clear from which fields finds had been recovered.
- In the case of linear Events (notably pipeline and road schemes) where watching briefs had been undertaken, it was not always clear from the reports how much of the corridor had been monitored and to what level of detail.
- It was not always clear during watching briefs whether topsoil had been completely or only partially stripped.

9.4.3 Methodological weaknesses

A fundamental requirement in using the Events data either to test the existing HLC models or to construct new models is to calculate the overall area, and the area of each HLC Type, surveyed by the Events. The Events Record consists of a series of polygons defining the extent of the Events but for the purposes of model building and testing many of these polygons were considered too tightly defined. This is particularly the case with road schemes in which the extent of the HLC Type Communications is likely to be overstated.

An additional consideration is the high probability that many of the Events offer keyhole views of archaeological activity which extends beyond the confines of the individual trench or area of survey. For these reasons the methodology was designed to more fully represent the area of archaeological activity revealed than is achieved by the Events Record polygons.

There are a number of ways this could be done in GIS - for instance by creating buffers set at a pre-determined distance (say 50 or 100m) around each Event polygon. The technique used, however, was to create new polygons using field boundaries marked on current OS mapping to define their boundaries. Field morphology forms the

basis for HLC polygons and this technique has the advantage of attaining a similar granularity of characterisation for both HLC and the lowland Events.

The weakness of the technique is that present day fields are an arbitrary measure of archaeological activity and that the resulting polygons form a set of land parcels of varying sizes, which may introduce an element of bias into measurements of area per HLC Type in the analysis. It should be noted that whilst the mean average size of the lowland Events polygons (in other words, the average field size) is 4.7ha there is considerable variation in polygon size from one HLC Type to another. This variation is set out in the table below.

HLC Type	Mean polygon size
Dunes	12.17
Military	8.36
Farmland Medieval	6.06
Farmland Post Medieval	5.79
Farmland C20	5.20
Recreational	4.20
Industrial: Disused	3.31
Upland Rough Ground	3.28
Ancient Woodland	2.64
Industrial: Working	2.46
Ornamental	2.44
Coastal Rough Ground	1.81
Farmland Prehistoric	1.27
Plantation and Scrub	1.03
Settlement C20	0.86
Water: Natural	0.78
Communications	0.52
Settlement older core (pre- 1907)	0.42
Mean average	4.70

Table 65. Comparison of polygon size for each HLC Type.

The range of polygon sizes listed in this table suggests that a biased analysis is likely, especially when point data is analysed. The analysis will favour those HLC Types in the lower half of the table. For instance 10 sites in Farmland Prehistoric would produce a higher PS/PA value than 10 sites 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.

9.5 Testing the models: conclusions

Testing of the models was carried out using data extracted from the Cornwall events record. Two test samples were used: the first was made up of all sites recorded in the events dataset (an internal sample); the second used only those sites which were previously unrecorded (an independent sample).

Testing was based both on numbers of sites (point data) and the area surveyed (polygons). In some cases the test results based on site numbers differ considerably from those based on site area. This is most likely because the method used for defining

the polygons (based on present day boundaries of the fields in which each event took place) may have distorted the test results. This is largely due to differences in the mean field size for each HLC Type.

For some events the exact location of features was not always clear from the accompanying reports and other documentation, particularly in the case of find spots, and this may have introduced an element of inaccuracy to some of the events data. A further weakness, or at least an area of uncertainty inherent in the test sample, was that geophysical anomalies which had not been further investigated by excavation were assumed to represent archaeological features, whereas experience shows that in some cases these anomalies turn out to be the result of natural agencies.

Notwithstanding these caveats the events record dataset does provide a test sample which can be expected to provide some measure of the veracity of the models. Furthermore, the distribution of the test events, whilst not even, reflects a good spread of sites across the whole project area.

One striking aspect of the tests is the higher number of sites recorded in the events record than might be expected from analysis of the distribution of known sites listed in the HER. This is more marked for some site types, such as open settlements than for others, such as barrows. Taking all the site types together (including find spots) it could reasonably be predicted that the area covered by the events (54.36km²) would reveal 122 sites, based on the number of known sites per square kilometre recorded throughout lowland Cornwall. The actual figure is 421 sites – three and a half times as many. The implication is that there are more below-ground archaeological remains in lowland Cornwall than suggested by analysis of site densities of known sites (i.e. those listed in the HER).

The test validated the rounds and enclosures model in that the high probability zone performs as well as or better than expected, especially when the test is based in site area. This is the case whether the test is carried out using all records for rounds and enclosures or only the newly recorded examples.

The open settlements model was rejected, with only half as many sites captured in the high probability zone as were predicted and both medium and low probability zones (particularly the medium zone) capturing many more sites than expected. This model performed worst when the test was based only on newly recorded sites. However, when the distribution of the new sites was tested against the rounds and enclosures model a close fit was achieved for the high probability zone, particularly when the test was based on site area. This suggests that the model for rounds and enclosures is an indicator of those areas where undiscovered open settlements are most likely to be located in the future.

The distribution of field systems identified in the events record fits fairly well with the field systems HLC model, although the test suggests that the likelihood of finding field systems in the medium probability zone is understated in the original model. This is more pronounced when measuring the model by site area rather than point data and applies to the previously unrecorded sites as well as the complete dataset.

The events record data for barrows was a very close fit to the barrows HLC model. The main difference being that the high probability zone performed better than predicted at the expense of the medium probability zone. This discrepancy is slightly more marked when the test was based on site area rather than point data.

When the test was based only on the newly recorded barrows the model was rejected, with the medium probability zone performing far better than expected at the expense of the high probability zone. Bearing in mind that the original barrows HLC model largely reflects the distribution of sites with extant remains, a case can be made for suggesting that this model is based on incomplete information and that more plough-levelled barrows remain to be discovered in the medium probability zone – most notably within the HLC Type Farmland Medieval, which forms the bulk of the zone.

However, the results cannot be regarded as conclusive due to the very limited size of the new site dataset.

The model for prehistoric and Romano-British find spots was clearly rejected by the events record test and, whilst the sample derived from the events record is too small to produce a revised model, it does demonstrate that the HER-based model for prehistoric finds cannot be regarded as reliable. It is reasonable to suggest from this evidence that the pattern of finds distribution presented by the HER derives from a biased sample and that further finds retrieval in lowland Cornwall would provide a great deal more evidence from HLC Types such as Farmland Medieval which appear to be currently under-represented in the HER.

10 The high level models: discussion and conclusions

10.1 Discussion

10.1.1 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 Type for all site types (including find spots) apart from hut circles/round houses (Coastal Rough Ground contains 58 sites; Farmland Medieval 55). Because of its large area this Type weakens the models regardless of the probability zone in which it is ranked. If it is placed 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 placed 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 precise and will score 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 this would be regarded as a low gain measure and the model deemed to be weak.

However, a good predictive model should be both accurate and precise and the results of Lowland Cornwall show that Kvamme's gain is really only a measure of precision. The experimental field systems model made using Indicative Values (section 7.2.2), for instance, contains a high probability zone with a high Kvamme's gain of 0.83 but it only captures 27% of the sites, whereas the low probability zone captures 57% of the sites (although one is far more likely to encounter a site in the high probability zone because it only covers 4.5% of the project area). 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 in this zone. And 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 rounds and 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.

10.1.2 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 (section 10.1.4 below). Essentially the three zone models can be sub-divided into two broad types;

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 rounds and enclosures and early medieval settlements, those of the second category capture Bronze Age barrows and hut circles/round houses. 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 survival of the monuments. Extant monuments are much more likely to be found in Rough Ground and Recently Enclosed Land – the barrows and hut circles datasets are both

characterised by high numbers of extant sites (70% of hut circles in the dataset have extant remains as opposed to only 8% surviving as cropmarks; for barrows the equivalent percentages are 51% and 19%), and extant field systems are located primarily in Farmland Prehistoric, Coastal Rough Ground, Upland Rough Ground and Farmland C20. By contrast rounds and 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 two models may be somewhat misleading in that they are 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/round house model was clearly rejected. However, when this same new data was tested against the rounds and enclosures model it achieved a much closer fit, suggesting that the real distribution pattern of open settlements is similar to that of the rounds and 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 position 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 here, 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 provides evidence of continuity – the settlement zone of early medieval farmers being the same as their forbears.

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 by sites typical of rough ground, such as barrows and by sites typical of Farmland Medieval, such as rounds. 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 (Lowland Cornwall Volume 3) was to define these two types of Farmland C20 so that more precise models could be achieved.

Overall the models do corroborate the assertion that in lowland Cornwall the medieval settlement and farming heartland is a continuation of the prehistoric and Romano-British farming heartland. The models for both early medieval settlements and rounds 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/round houses) appears to contradict this pattern, testing suggests that the model is questionable and the locations of previously unrecorded round houses discovered during interventions are, for the most part, consistent with the high probability zone of the rounds and enclosures model. There is little doubt that many open settlements remain undiscovered and the inference is that their distribution reflects that of rounds and 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. However, 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 rounds and 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 more difficult to interpret. 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 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 far 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 new barrows are most likely to be found. It seems that the majority of barrows were sited away from the main areas of settlement although others were built closer to home.

10.1.3 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. One exception to this was the model for Iron Age and Romano-British find spots, for which it was possible to identify three probability zones, and in which Farmland Post Medieval was ranked in the low probability zone. Farmland Medieval was invariable ranked in the low probability zone of the models.

However, all the models for find spots were emphatically rejected by testing with events record data, so that no firm conclusions can be drawn from the models other than to say that the data currently held in the HER is unlikely to be representative of the true distribution of prehistoric finds in lowland Cornwall. The distribution, for a large part, does seem to reflect the main areas of activity of a few finds collectors over time and 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.

There are further weaknesses with the find spots models, most notable that resources did not allow any detailed analysis of the size and nature of the assemblages and they were consequently all treated equally.

10.1.4 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, rounds and enclosures, and field systems. Early medieval settlements are rare.

- **Farmland Medieval.** Early medieval settlements, rounds and enclosures, and field systems are typical.
- **Farmland Post Medieval.** Barrows are typical. Rounds and enclosures, field systems and early medieval settlements are rare.
- **Farmland Prehistoric.** Field systems and round houses are typical. Early medieval settlements and barrows are less common.
- **Upland and Coastal Rough Ground.** Barrows, round houses and field systems are typical. Rounds and enclosures and early medieval settlements are rare.

10.2 Conclusions

- There are statistically significant correlations between HLC Types and all the site types considered except hillforts.
- It was only possible to create two zone models for find spots, the distribution of find spots appears to be heavily influenced by the historical activities of individual finds collectors and the find spots models were all clearly rejected when tested with events record data. This suggests that data on finds held in the HER is not representative of the true distribution of prehistoric artefacts in lowland Cornwall. Further research – possibly a programme of systematic field walking – would be useful.
- For all the monument types considered, three zone models were built.
- The model for hut circles/round houses was rejected when tested, but the test showed that the rounds and enclosures model provided a better match for the round houses and other evidence for open settlement recorded in the events record.
- The model for Bronze Age barrows was rejected when tested but the test sample was too small for this test to be seen as conclusive.
- All the other models were verified by events record testing.
- The assertion that the medieval farming and settlement heartland was a continuation of that of prehistoric and Romano-British times is broadly corroborated by the models. The models for early medieval settlements and rounds and enclosures share similarities and the test sample of open settlements also fit the rounds and enclosures model. The important HLC Types are Farmland Medieval, Farmland C20 and Farmland Prehistoric.
- Despite its inconclusive testing, the barrows model suggests that in the main barrows were sited away from the main settlement areas.
- The HLC Type Farmland Prehistoric was ranked in the high probability zone of all the models, underlining the uniquely heritage-rich landscape of West Penwith.
- Whilst the models are accurate (with high percentages of sites captured in their high probability zones), the large area taken up by the HLC Type farmland Medieval means that many of them lack precision.

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12 Project archive

The HE project number is **2009028**

The project's documentary, photographic and drawn archive is housed at the offices of Historic Environment, Cornwall Council, Kennall Building, Old County Hall, Station Road, Truro, TR1 3AY. The contents of this archive are as listed below:

1. A project file containing project correspondence and administration.
2. A digital file containing Excel tables, draft documents and notes held in the directory G:\TWE\Waste & Env\Strat Waste & Land\Historic Environment\Projects\Sites_L\ Lowland_Cornwall
3. GIS shapefiles and accompanying metadata are held in the directory: L:\Historic Environment (Data)\HE_Projects\Sites_L\Lowland_Cornwall_2009028\Final report

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 c10 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

Results of Chi-squared tests for each site type

Field systems				
HLC Type	Area km2	Sites	Expected	Chi-Squared
Farmland Medieval	1663.638659	246	275.89663	3.23965081
Farmland Post medieval	510.1569539	44	84.604061	19.4871234
Farmland C20	343.1720638	61	56.911407	0.29373003
Plantation and Scrub	115.3667198	4	19.132334	11.9686142
Settlement C20	98.4644758	4	16.329278	9.30911274
Upland Rough Ground	90.44596739	25	14.999494	6.66756635
Farmland Prehistoric	87.64975979	86	14.535773	351.349446
Ancient Woodland	71.17359662	0	11.803378	11.8033779
Coastal Rough Ground	48.20205572	50	7.9937941	220.736399
Ornamental	43.78704668	0	7.2616122	7.26161222
Other (Expected<5)	117.7780979	9	19.532235	5.67922567
Chi-Sq Value				647.795858
<i>Other HLC Types</i>				
<i>Industrial: Working</i>	<i>5.01474451</i>	<i>0</i>	<i>0.8316416</i>	
<i>Rough Ground/Industrial</i>	<i>3.688176122</i>	<i>1</i>	<i>0.6116445</i>	
<i>Water: Reservoirs</i>	<i>2.87835604</i>	<i>0</i>	<i>0.4773445</i>	
<i>Recreational</i>	<i>19.85405726</i>	<i>0</i>	<i>3.2925825</i>	
<i>Water: Natural</i>	<i>18.75527031</i>	<i>0</i>	<i>3.1103605</i>	
<i>Military</i>	<i>17.65064244</i>	<i>0</i>	<i>2.9271698</i>	
<i>Settlement older core (pre- 1907)</i>	<i>16.64774352</i>	<i>0</i>	<i>2.7608498</i>	
<i>Communications</i>	<i>13.24775882</i>	<i>0</i>	<i>2.1969988</i>	
<i>Industrial: Disused</i>	<i>11.43621333</i>	<i>1</i>	<i>1.8965734</i>	
<i>Dunes</i>	<i>8.605135567</i>	<i>7</i>	<i>1.4270695</i>	
5% Significance Chi-Sq Value =				19.6752

Barrows				
HLC Type	Area km2	Sites	Expected	Chi-Squared
Farmland Medieval	1663.63866	684	1105.67271	160.814204
Farmland Post medieval	510.156954	633	339.055972	254.8343
Farmland C20	343.172064	324	228.075962	40.3436692
Plantation and Scrub	115.36672	41	76.6740021	16.5979914
Settlement C20	98.4644758	59	65.4405832	0.63387443
Upland Rough Ground	90.4459674	85	60.1113936	10.3049138
Farmland Prehistoric	87.6497598	83	58.253003	10.5130007
Ancient Woodland	71.1735966	1	47.3027621	45.3239025
Coastal Rough Ground	48.2020557	114	32.0356211	209.709042
Ornamental	43.7870467	18	29.1013571	4.2348585
Recreational	19.8540573	22	13.1952268	5.87515722
Water: Natural	18.7552703	8	12.4649608	1.59935318
Military	17.6506424	15	11.7308128	0.91106942
Settlement older core (pre- 1907)	16.6477435		11.0642751	11.0642751
Communications	13.2477588	2	8.80460752	5.2589151
Industrial: Disused	11.4362133	4	7.60063428	1.70572175
Dunes	8.60513557	7	5.71906858	0.28689729
Other (Expected<5)	11.5812767	20	7.69704499	19.6650406
Chi-Sq Value				799.676186
<i>Other HLC Types</i>				
<i>Industrial: Working</i>	<i>5.01474451</i>		<i>3.273115</i>	
<i>Rough Ground/Industrial</i>	<i>3.688176122</i>	<i>19</i>	<i>2.40726612</i>	
<i>Water: Reservoirs</i>	<i>2.87835604</i>	<i>1</i>	<i>1.87869797</i>	
5% Significance Chi-Sq Value =				28.8693

Enclosures and Rounds				
HLC Type	Area km2	Sites	Expected	Chi-Squared
Farmland Medieval	1663.638659	1175	1020.6611	23.3383061
Farmland Post medieval	510.1569539	243	312.98705	15.6498063
Farmland C20	343.1720638	228	210.53993	1.44796265
Plantation and Scrub	115.3667198	21	70.778784	35.0094647
Settlement C20	98.4644758	33	60.409067	12.4361619
Upland Rough Ground	90.44596739	26	55.489621	15.6720797
Farmland Prehistoric	87.64975979	148	53.774116	165.107634
Ancient Woodland	71.17359662	6	43.665804	32.4902482
Coastal Rough Ground	48.20205572	25	29.572505	0.70700137
Ornamental	43.78704668	17	26.863847	3.62179993
Recreational	19.85405726	11	12.180688	0.11444545
Water: Natural	18.75527031	2	11.50657	7.8541974
Military	17.65064244	6	10.828868	2.15331538
Settlement older core (pre- 1907)	16.64774352	5	10.213578	2.66130039
Communications	13.24775882	1	8.1276495	6.25068629
Industrial: Disused	11.43621333	2	7.0162459	3.58635133
Dunes	8.605135567	5	5.2793477	0.01478121
Other (Expected<5)	11.58127667	3	7.1052439	2.37191399
Chi-Sq Value				330.487456
<i>Other HLC Types</i>				
<i>Industrial: Working</i>	<i>5.01474451</i>	<i>6</i>	<i>3.0844628</i>	
<i>Rough Ground/Industrial</i>	<i>3.688176122</i>	<i>2</i>	<i>2.2685188</i>	
<i>Water: Reservoirs</i>	<i>2.87835604</i>	<i>1</i>	<i>1.7704157</i>	
5% Significance Chi-Sq Value =				28.8693

Hut circles/Round houses				
HLC Type	Area km2	Sites	Expected	Chi-Squared
Farmland Medieval	1663.638659	55	150.20459	60.3437925
Farmland Post medieval	510.1569539	40	46.060434	0.79740586
Farmland C20	343.1720638	27	30.983904	0.51224961
Plantation and Scrub	115.3667198	7	10.416091	1.1203509
Settlement C20	98.4644758	14	8.8900415	2.93718269
Upland Rough Ground	90.44596739	34	8.1660761	81.7273333
Farmland Prehistoric	87.64975979	33	7.9136155	79.524547
Ancient Woodland	71.17359662	1	6.4260356	4.58165254
Other (Expected<5)	209.7672003	77	18.924906	178.215767
Chi-Sq Value				409.760281
<i>Other HLC Types</i>				
<i>Industrial: Working</i>	<i>5.01474451</i>		<i>0.4527652</i>	
<i>Rough Ground/Industrial</i>	<i>3.688176122</i>		<i>0.3329936</i>	
<i>Water: Reservoirs</i>	<i>2.87835604</i>		<i>0.2598775</i>	
<i>Recreational</i>	<i>19.85405726</i>	<i>1</i>	<i>1.7925591</i>	
<i>Water: Natural</i>	<i>18.75527031</i>	<i>1</i>	<i>1.6933532</i>	
<i>Military</i>	<i>17.65064244</i>	<i>8</i>	<i>1.5936199</i>	
<i>Settlement older core (pre- 1907)</i>	<i>16.64774352</i>	<i>1</i>	<i>1.5030713</i>	
<i>Communications</i>	<i>13.24775882</i>		<i>1.1960976</i>	
<i>Industrial: Disused</i>	<i>11.43621333</i>		<i>1.032539</i>	
<i>Dunes</i>	<i>8.605135567</i>	<i>7</i>	<i>0.7769301</i>	
<i>Coastal Rough Ground</i>	<i>48.20205572</i>	<i>58</i>	<i>4.3520089</i>	
<i>Ornamental</i>	<i>43.78704668</i>	<i>1</i>	<i>3.9390903</i>	
5% Significance Chi-Sq Value =				16.9190

Early medieval sites				
HLC Type	Area km2	Sites	Expected	Chi-Squared
Farmland Medieval	1663.63866	1267	1103.58654	24.1974314
Farmland Post medieval	510.156954	91	338.416244	180.88611
Farmland C20	343.172064	106	227.64563	65.0030454
Plantation and Scrub	115.36672	40	76.5293342	17.43635
Settlement C20	98.4644758	234	65.3171104	435.627312
Upland Rough Ground	90.4459674	19	59.9979758	28.0148455
Farmland Prehistoric	87.6497598	134	58.1430916	98.967399
Ancient Woodland	71.1735966	4	47.2135116	39.5523976
Coastal Rough Ground	48.2020557	27	31.9751765	0.77411243
Ornamental	43.7870467	58	29.0464489	28.8609505
Recreational	19.8540573	16	13.1703301	0.60795983
Water: Natural	18.7552703	5	12.441442	4.45085535
Military	17.6506424	11	11.7086792	0.0428935
Settlement older core (pre- 1907)	16.6477435	49	11.0433991	130.458344
Communications	13.2477588	13	8.78799505	2.01877511
Industrial: Disused	11.4362133	2	7.58629346	4.11356017
Dunes	8.60513557	40	5.70827789	206.002971
Other (Expected<5)	11.5812767		7.68252226	7.68252226
Chi-Sq Value				1274.69783
<i>Other HLC Types</i>				
<i>Industrial: Working</i>	<i>5.01474451</i>		<i>3.0498766</i>	
<i>Rough Ground/Industrial</i>	<i>3.68817612</i>		<i>2.24308179</i>	
<i>Water: Reservoirs</i>	<i>2.87835604</i>		<i>1.75056391</i>	
5% Significance Chi-Sq Value =				28.8693

Prehistoric finds (Periods Palaeolithic – Bronze Age and 'Prehistoric')				
HLC Type	Area km2	Sites	Expected	Chi-Squared
Farmland Medieval	1663.63866	325	686.351552	190.24499
Farmland Post medieval	510.156954	212	210.470594	0.01111358
Farmland C20	343.172064	171	141.579229	6.11376241
Plantation and Scrub	115.36672	15	47.5957485	22.3230615
Settlement C20	98.4644758	80	40.6225507	38.1705108
Upland Rough Ground	90.4459674	68	37.3144311	25.2343158
Farmland Prehistoric	87.6497598	228	36.1608264	1017.73859
Ancient Woodland	71.1735966	10	29.3634127	12.7690114
Coastal Rough Ground	48.2020557	131	19.8862629	620.843777
Ornamental	43.7870467	11	18.0648047	2.76291198
Recreational	19.8540573	4	8.19099925	2.14436288
Water: Natural	18.7552703	8	7.73768319	0.00889286
Military	17.6506424	6	7.28195739	0.22568311
Settlement older core (pre- 1907)	16.6477435	13	6.86820094	5.47435347
Communications	13.2477588	4	5.46550165	0.39295479
Other (Expected<5)	31.6226256	30	13.0462454	22.0316105
Chi-Sq Value				1966.48991
<i>Other HLC Types</i>				
<i>Industrial: Working</i>	<i>5.01474451</i>	<i>2</i>	<i>2.06888537</i>	
<i>Rough Ground/Industrial</i>	<i>3.68817612</i>	<i>1</i>	<i>1.52159569</i>	
<i>Industrial: Disused</i>	<i>11.4362133</i>	<i>7</i>	<i>4.71812958</i>	
<i>Water: Reservoirs</i>	<i>2.87835604</i>	<i>6</i>	<i>1.18749593</i>	
<i>Dunes</i>	<i>8.60513557</i>	<i>14</i>	<i>3.5501388</i>	
5% Significance Chi-Sq Value =				26.2962

Iron Age and Romano-British finds				
HLC Type	Area km2	Sites	Expected	Chi-Squared
Farmland Medieval	1663.63866	99	169.5017	29.32414
Farmland Prehistoric	87.6497598	41	8.930295	115.166
Farmland Post medieval	510.156954	30	51.97792	9.292965
Settlement C20	98.4644758	27	10.03216	28.69843
Coastal Rough Ground	48.2020557	37	4.911121	209.6662
Other (Expected<5)	781.723492	91	79.64679	1.618339
Chi-Sq Value				393.766
<i>Other HLC Types</i>				
<i>Upland Rough Ground</i>	<i>90.4459674</i>	<i>14</i>	<i>9.21519</i>	
<i>Farmland C20</i>	<i>343.172064</i>	<i>23</i>	<i>34.96448</i>	
<i>Dunes</i>	<i>8.60513557</i>	<i>12</i>	<i>0.876744</i>	
<i>Recreational</i>	<i>19.8540573</i>	<i>8</i>	<i>2.022853</i>	
<i>Settlement older core (pre- 1907)</i>	<i>16.6477435</i>	<i>10</i>	<i>1.696174</i>	
<i>Plantation and Scrub</i>	<i>115.36672</i>	<i>6</i>	<i>11.75427</i>	
<i>Ancient Woodland</i>	<i>71.1735966</i>	<i>5</i>	<i>7.251603</i>	
<i>Industrial: Disused</i>	<i>11.4362133</i>	<i>2</i>	<i>1.165192</i>	
<i>Ornamental</i>	<i>43.7870467</i>	<i>5</i>	<i>4.461293</i>	
<i>Water: Natural</i>	<i>18.7552703</i>	<i>5</i>	<i>1.910902</i>	
<i>Water: Reservoirs</i>	<i>2.87835604</i>	<i>1</i>	<i>0.293265</i>	
<i>Communications</i>	<i>13.2477588</i>		<i>1.349763</i>	
<i>Rough Ground/Industrial</i>	<i>3.68817612</i>		<i>0.375774</i>	
<i>Military</i>	<i>17.6506424</i>		<i>1.798356</i>	
<i>Industrial: Working</i>	<i>5.01474451</i>		<i>0.510933</i>	
5% Significance Chi-Sq Value =				12.5916

PAS data				
HLC Type	Area km2	Sites	Expected	Chi-Squared
Farmland Medieval	1663.638659	105	120.4766	1.98814718
Farmland Post medieval	510.1569539	50	36.944306	4.61373216
Farmland C20	343.1720638	6	24.851673	14.3002678
Plantation and Scrub	115.3667198		8.3545729	8.35457287
Settlement C20	98.4644758	1	7.1305541	5.27079567
Upland Rough Ground	90.44596739	4	6.5498735	0.9926688
Farmland Prehistoric	87.64975979	37	6.3473791	148.02695
Ancient Woodland	71.17359662	5	5.1542161	0.0046142
Other (Expected<5)	209.7672003	23	15.190822	4.01448002
Chi-Sq Value				187.566229
<i>Other HLC Types</i>				
<i>Coastal Rough Ground</i>	<i>48.20205572</i>	<i>4</i>	<i>3.4906738</i>	
<i>Ornamental</i>	<i>43.78704668</i>	<i>1</i>	<i>3.1709498</i>	
<i>Industrial: Working</i>	<i>5.01474451</i>		<i>0.3631554</i>	
<i>Rough Ground/Industrial</i>	<i>3.688176122</i>		<i>0.2670886</i>	
<i>Water: Reservoirs</i>	<i>2.87835604</i>		<i>0.2084434</i>	
<i>Recreational</i>	<i>19.85405726</i>		<i>1.4377818</i>	
<i>Water: Natural</i>	<i>18.75527031</i>	<i>1</i>	<i>1.3582103</i>	
<i>Military</i>	<i>17.65064244</i>		<i>1.2782159</i>	
<i>Settlement older core (pre- 1907)</i>	<i>16.64774352</i>		<i>1.2055885</i>	
<i>Communications</i>	<i>13.24775882</i>	<i>1</i>	<i>0.95937</i>	
<i>Industrial: Disused</i>	<i>11.43621333</i>		<i>0.8281823</i>	
<i>Dunes</i>	<i>8.605135567</i>	<i>16</i>	<i>0.6231627</i>	
5% Significance Chi-Sq Value =				15.5073

Results of Chi-squared tests for amalgamated HLC areas

Field systems				
Character area	Area km2	Sites	Expected	Chi-Squared
Anciently enclosed land	1751.288419	332	290.432407	5.94928357
Recently enclosed land	853.3290177	105	141.515468	9.42214621
Rough Ground	94.13414351	26	15.6111384	6.91355377
Woodland	186.5403166	4	30.9357115	23.4529131
Settlement	115.1122193	4	19.0901274	11.9282569
Coastal	75.56246157	57	12.5312241	157.803581
Imposed	113.868819	1	18.8839228	16.9368779
Chi-Sq Value				232.406612
5% Significance Chi-Sq Value =				14.0671

Barrows				
Character area	Area km2	Sites	Expected	Chi-Squared
Anciently enclosed land	1751.288419	767	1163.92572	135.360893
Recently enclosed land	853.3290177	957	567.131934	268.01014
Rough Ground	94.13414351	104	62.5625963	27.445447
Woodland	186.5403166	42	123.976764	54.205237
Settlement	115.1122193	59	76.5048583	4.00523666
Coastal	75.56246157	129	50.2196504	123.583964
Imposed	113.868819	62	75.6784806	2.47231222
Chi-Sq Value				615.08323
5% Significance Chi-Sq Value =				14.0671

Enclosures and rounds				
Character area	Area km2	Sites	Expected	Chi-Squared
Anciently enclosed land	1751.288419	1323	1074.4352	57.5041279
Recently enclosed land	853.3290177	471	523.526979	5.27018397
Rough Ground	94.13414351	28	57.752359	15.327562
Woodland	186.5403166	27	114.444589	66.8144835
Settlement	115.1122193	38	70.6226451	15.0693446
Coastal	75.56246157	32	46.3584226	4.44718107
Imposed	113.868819	38	69.859805	14.5297739
Chi-Sq Value				178.962657
5% Significance Chi-Sq Value =				14.0671

Hut circles/Round houses				
Character area	Area km2	Sites	Expected	Chi-Squared
Anciently enclosed land	1751.288419	88	158.11821	31.0942264
Recently enclosed land	853.3290177	67	77.0443382	1.30948921
Rough Ground	94.13414351	34	8.49906969	76.5139563
Woodland	186.5403166	8	16.8421265	4.64212169
Settlement	115.1122193	15	10.3931128	2.04206476
Coastal	75.56246157	66	6.82229213	513.317378
Imposed	113.868819	10	10.2808502	0.00767221
Chi-Sq Value				628.926908
5% Significance Chi-Sq Value =				14.0671

Early medieval sites				
Character area	Area km2	Sites	Expected	Chi-Squared
Anciently enclosed land	1751.288419	1401	1161.72963	49.2802358
Recently enclosed land	853.3290177	197	566.061874	240.621517
Rough Ground	94.13414351	19	62.4445537	30.2256824
Woodland	186.5403166	44	123.742846	51.3881948
Settlement	115.1122193	283	76.3605095	559.18798
Coastal	75.56246157	72	50.1248964	9.54655657
Imposed	113.868819	100	75.535691	7.92343863
Chi-Sq Value				948.173605
5% Significance Chi-Sq Value =				14.0671

Prehistoric finds (Periods Palaeolithic – Bronze Age and 'Prehistoric')				
Character area	Area km2	Sites	Expected	Chi-Squared
Anciently enclosed land	1751.288419	553	722.512378	39.7701788
Recently enclosed land	853.3290177	383	352.049823	2.72095988
Rough Ground	94.13414351	69	38.8360268	23.4283823
Woodland	186.5403166	25	76.9591613	35.0803516
Settlement	115.1122193	93	47.4907516	43.6104213
Coastal	75.56246157	153	31.1740849	476.086264
Imposed	113.868819	40	46.9777738	1.03643327
Chi-Sq Value				621.732991
5% Significance Chi-Sq Value =				14.0671

Iron Age and Romano-British finds				
Character area	Area km2	Sites	Expected	Chi-Squared
Anciently enclosed land	1751.288419	140	178.432008	8.27777079
Recently enclosed land	853.3290177	53	86.9423955	13.2511441
Rough Ground	94.13414351	14	9.59096406	2.02686589
Woodland	186.5403166	11	19.0058719	3.37232541
Settlement	115.1122193	37	11.7283391	54.454159
Coastal	75.56246157	54	7.69876716	278.460709
Imposed	113.868819	16	11.6016539	1.66747335
Chi-Sq Value				361.510447
5% Significance Chi-Sq Value =				14.0671

PAS data				
Character area	Area km2	Sites	Expected	Chi-Squared
Anciently enclosed land	1751.288419	142	126.823981	1.81599364
Recently enclosed land	853.3290177	56	61.7959796	0.54361756
Rough Ground	94.13414351	4	6.81696215	1.16404867
Woodland	186.5403166	5	13.5087889	5.35943596
Settlement	115.1122193	1	8.33614258	6.45610214
Coastal	75.56246157	21	5.47204682	44.0634626
Imposed	113.868819	2	8.2460986	4.73117647
Chi-Sq Value				64.133837
5% Significance Chi-Sq Value =				14.0671

Appendix 3. Map of Cornwall showing places mentioned in the report text

