Are linear arrangements of Early Bronze Age round barrows oriented towards predictable extreme solar events on the horizon?

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Abstract

The aim of the thesis was to investigate the orientations of lines of Bronze Age burial mounds (‘round barrows’) in Dorset and the New Forest.

Doing this required identifying as many as possible lines of round barrows in the study area, which contained 3,587 sites of individual barrows. A set of criteria to define lines of barrows was produced. Two methods were used to identify linear arrangements of barrows. The first used a computer programme developed for this purpose to synthesise lines from the 3,587 sites. The second searched the records of 'Historic England'. All potential lines were evaluated for their suitability against preset criteria by examining maps, LIDAR images, and other sources of information. Seventy-one lines were identified as being suitable for the study.

The researcher generated models of the bare horizons potentially visible from defined points. Using Smith’s dedicated GIS computer programme, *Horizon,* enabled him to record the declination of each line 'pointing ‘ outwards towards the horizon. A basic case-study analysis found that two (of the 142) directions were towards the Bronze Age Winter Solstice. The researcher then used a specialist programme (Silva’s *skyscapeR)* which can identify recurring orientations, beyond those expected by chance alone. This found no evidence that lines were organised in any directions that could not be accounted for by chance. He also noted a group of lines oriented west-east, that occurred in one area of Dorset and nowhere else.

These results highlight the importance of the two lines identified here as ‘pointing’ towards the Winter Solstice sunset, given the rarity of lines that ‘point’ towards any astronomical events on the horizon, and also that of the Badbury Rings area, and also the need to accept that some directional organisation of lines may be influenced by non-celestial factors (or both?)

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I very much appreciate the encouragement of John Gale, former senior lecturer in archaeology at Bournemouth University, to look further into my initial observations at High Lea Farm.

In a completely other sphere, I also acknowledge the help, encouragement, and forbearance of my wife, Vanessa Bennett, who has accepted limitations on our life, quoting Agatha Christie's quip about the pleasant fate of archaeologists' wives as they get older.

PREFACE: The stimulus for the current study

All ideas come from somewhere. The stimulus for this study came from the writer's recognition that a round barrow cemetery on which he had first trained to excavate was organised to 'point' towards the Winter Solstice sunset at what seemed like a meaningful point on the horizon. This led to the question: was the cemetery unique or was it an instance of a more common pattern? The research presented in this dissertation attempts to answer this simple yet fundamental question.

The barrow cemetery that prompted the original question is at High Lea Farm in the parish of Hinton in Eastern Dorset. It was investigated through a campaign of annual excavations between 2002 and 2007 and was part of a wider study directed by John Gale, into the prehistoric landscape of Knowlton and the Allen Valley (Gale 2005, Gale 2017, Gale and Burrow 2022). The writer took part in the final excavation at the site (2007) and returned to look at it some seven years later. Struck by the apparent pattern, he investigated it further, encouraged by John Gale, and the findings were later published (Bennett and Gale 2017).

Figure 1: Locations of places mentioned in the text of the Preface. The study area is the county of Dorset and the New Forest District, indicated by the blue boundary line (personal collection 2024).

The theodolite-based study of the cemetery established that in the Early Bronze Age the second largest barrow in the cemetery (HLF9) would have offered a view of the Winter

Solstice sunset occurring against a hill that was very important to Bronze Age people. From HLF9 looking up, along a line of three barrows to the largest barrow of the group the barrows would have appeared to point to this annual event in midwinter (Figure 2, Figure 3). From midsummer the daily sunset would have been seen to gradually move southward along the horizon from its position at the Summer Solstice, with the pace of apparent movement slowing down after the September equinox, in September, and then stopping at the edge of the hill at the Winter Solstice in December. After pausing for a few days, it would have been seen to reverse direction and gradually pick up speed in its movement back northwards. It seems reasonable to suppose that the barrows forming the cemetery were organised to draw attention to this predictable, annual solar event on the horizon. The winter solstice sunset is still seen to occur close to this position (Figure 4).

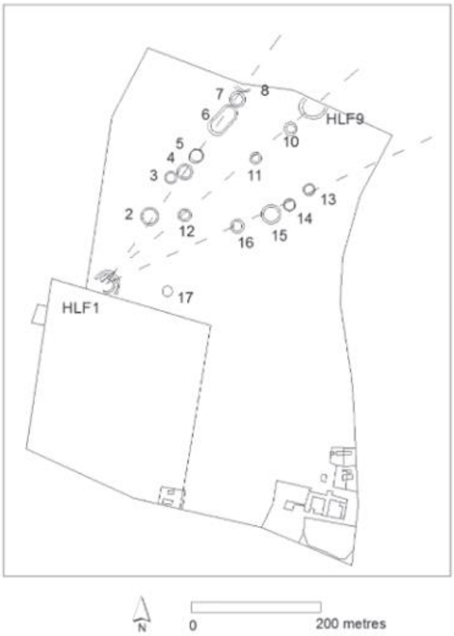

Figure 2: Plan of the recorded barrows in the High Lea Barrow Cemetery in relation to modern settlement features (Bennett, and Gale, 2017, p 127). With permission of the Editor of the *Proceedings of the Dorset Natural History and Archaeological Society*.

The hills against which the winter solstice sunset would have been seen to have abutted in the early second millennium BC was the site of a rich cluster of structures and objects dated to the Bronze Age (Bennett and Gale 2017, p131). Close by what is now Badbury Rings, it had the largest concentration of round barrows in the study area, the next largest being around Knowlton (Figure 5). The nearby ‘Badbury Barrow’ contained a unique sandstone block engraved with images of bronze dagger and axes similar to those found on sarsens at Stonehenge (Figure 6).

Figure 3: The view south-westerly from the edge of barrow HLF9 . Beyond the obstruction of the spoil heap is the near horizon and beyond that the double hill (High Wood and Badbury). Photograph taken in 2015 (personal collection).

Thus, the idea of the current study was conceived. The main aim was to assess how commonly lines of round barrows in the region around High Lea Farm, defined as Dorset and the New Forest, point towards the location on the horizon where the Winter Solstice Sunset would have been seen to occur in the early second Millennium BC. The potential significance of the solar cycle to the people who built round barrows , as suggested from the organisation of High Lea Farm cemetery, will be discussed in Chapter 1, which focusses on the changes that occurred in Southern Britain in the late third millennium BC, associated with the movement into Britain of a significant number of ‘Beaker People’ from continental Europe.

Figure 4. The Winter Solstice sunset December 2015. A view taken after the solar filter had been removed from the camera (personal collection).

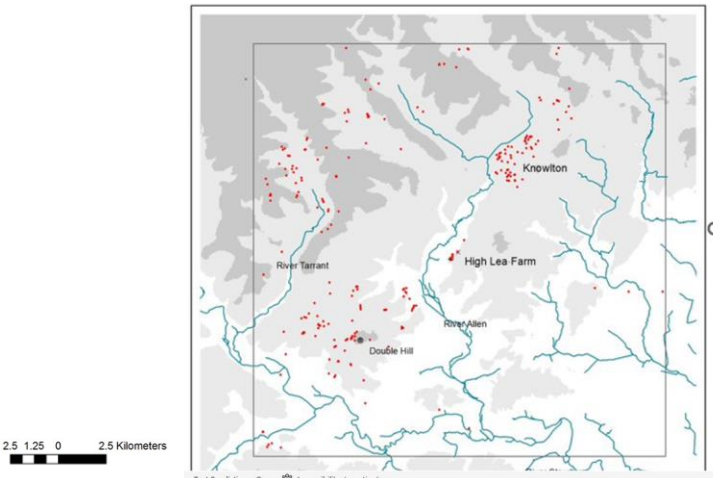

Figure 5: Location of ring ditches and round barrows in the area round High Lea Farm, both marked by red dots (Bennett and Gale 2017, p130). *With permission of the Editor of the Proceedings of the Dorset Natural History and Archaeological Society*.

Figure 6: A block of sandstone decorated with inscribed images of metal axes and metal knives, taken from a barrow close to the Badbury Rings in 1845. Copyright of the Trustees of the British Museum, shared with a Creative Contributions Attribution Share-Alike 4.0 International (CC BY -NC-SA4.0) License.

Chapter 1 2450 – 1600 BC in Southern England: the period during which lines of round barrows were built

1.A INTRODUCTION

This chapter provides a context for the large-scale development of round barrows in Southern Britain from 2450 BC through 1600 BC. It is a prelude to Chapter 2, which narrows its focus onto ways in which such round barrows were organised in the landscape of the study area of Dorset and the New Forest. Chapters, 3, 4, and 5 describe an attempt to answer questions about one type of such organisation, lines of barrows, which were constructed in the study area.

This introduction provides a brief preview of the topics to be covered within this chapter. Bibliographic references will be provided in the substantial sections that follow. The period covered is approximately 800 years, during which a significant number of people from the European mainland moved into Britain and who have been characterised by a new type of ceramic drinking vessel that they brought with them, the beaker, as well as other novel objects, often found in their graves. These 'Beaker People' introduced new types of objects made of metal, which could be reborn when worn out: indeed, the search for new sources of tin, copper, and gold may have been an important reason for 'Beaker People' moving to Britain. They brought a new way of burying their dead, under round earthen mounds. They brought new ideas about life, related to the sun.

This research study focusses on the area of what is now the county of Dorset and the New Forest District, effectively the coastal strip 40km inland from the coast, and 160 km from the Solent in the East to the western end of the Dorset chalkland (Figure 7) . This limited area makes the study manageable. Given that there are variations in burial monuments throughout Britain, the study should focus on the area close to where the pattern of interest was observed, at High Lea Farm. The biggest contrast between the two parts of the study area is that very few remains of the Neolithic have been found in the New Forest, and that the only known physical structures there dating to the early second millennium BC are round barrows and burnt mounds, the latter of which are rare in Dorset. Examples of objects from the study area will be noted in this review.

Figure 7: Locations referred to in Chapter 1. The study area is the county of Dorset and the New Forest District, indicated by the blue boundary lines (personal collection 2024).

1.B CONTINUITY BETWEEN THE LATE NEOLITHIC AND THE 'BEAKER PEOPLE'

Not all aspects of life changed dramatically during the period of 2300-1500BC. There was no dramatic change in the fairly sparse population density, peoples' lives being largely dependent upon pastoralism and limited agriculture, nor in the continued use of stone tools. Little will be said about those. The post mortem remains of most people were dealt with in ways that have not been evident to archaeology, and probably include cremation, excarnation, and deposition in rivers.

1.C DISCONTINUITY BETWEEN THE LATE NEOLITHIC AND THE SIGNIFICANT MIGRATION OF THE 'BEAKER PEOPLE' INTO BRITAIN.

This section describes and discusses the 'Beaker People' , who first came to Britain during the third millennium BC, who have been thus described because their burials in Britain were accompanied by a large hipped ceramic beaker, in contrast to the funerary customs of the indigenous British, who disposed of bodies in ways that left few remains. Early 'Beaker ' graves typically contained an unburnt skeleton, a beaker, and other items such as flint tools. At first 'Beaker People' were buried in individual graves that were covered with flattened earth, one person, one grave, but soon graves were covered by semi hemispheric mounds, the innovative 'round barrows' .They brought ways of life that differed from those of the current inhabitants, and over a period of centuries these evolved into different ways, probably eventually, merging with other populations of Britain. Recent systematic scientific research by Parker Pearson and colleagues (Parker Pearson et al. 2019) into the remains of Beaker People in Britain has provided more certain knowledge. A study of 370 skeletons and grave goods of people buried with beakers analysed skeletons using radiocarbon dating, and also isotopic analysis which provided indications of the types of areas where they had lived for the first few years of life. The sample of skeletons was not random but recruited pragmatically to reach a wide coverage. Researchers from this 'Beaker People' study examined remains from Dorset but not the New Forest. Key findings of the dates of skeletons analysed are listed in Table 1. Table 2 summarises dates for the two phases that this study focuses on (the Chalcolithic and the Early Bronze Age) and also two adjacent phases. The current research study is concerned with the round barrows that appeared in greater numbers within the Chalcolithic and the Early Bronze Age. It focusses on linear groups of round barrows in the study area.

Earliest barrow in Britain in burial 2460-2330 cal BC (p.75)
Latest barrow in Britain in burial 1805-1650 cal BC (p.78)
Earliest Beaker grave in Southern England containing copper 2420-2385 cal BC (p.116)
Earliest Beaker grave in Southern England containing gold 2420-2385 cal BC (p.116)
Earliest Beaker grave in Southern England containing bronze 2305-2130 cal BC (p.118)
Earliest Beaker grave for Dorset 2405-2270 cal BC (p.72, and p 77)
Earliest Beaker grave for Dorset containing copper 2150 – 1950 cal BC (p. 118)
Earliest grave for Dorset containing bronze 2150 – 1950 (p. 118)

Table 1 Estimates of Radiocarbon dates (with 95% confidence) of skeletons in the Beaker People Project with notable characteristics. Page numbers in the table refer to page numbers of Parker Pearson *et al* (2019).

Table 2 characterises the dates and features of these four phases.

Phase 1	**The Late Neolithic** began BC 3000 to 2900
	Characterised by henge monuments and Grooved Ware pottery
Phase 2	**The Chalcolithic** began BC 2450 to 2400
	The recognised 'Beaker package' of inhumation burials: copper and gold
Phase 3	**The Early Bronze Age** began BC 2200 to 2150
	Round barrows and associated funerary rites: inhumations dominant: First bronze. Continuing use of beakers
Phase 4	**Middle Bronze Age** began 1600-1550
	Round houses, cremations , late beakers

Table 2: Important characteristics of phases before and after the introduction of round barrows by 'The Beaker People'. From Needham and Anelay (2021, p 32).

1.C.1 The movement of Beaker People into Britain

Most of the changes observed during the period from 2450 BC to 1600 BC were associated with the immigration of Beaker People from continental Europe, particularly the Rhine Valley (Parker Pearson, p 8). Interestingly, a study of the genetic identities of Beaker People found in Britain noted that these were notably close to those from the area of Oostwoud, which is close to the Rhine (Olalde et al 2018, p4) . The title 'Beaker' refers to a characteristic type of ceramic container, probably drinking vessels, which have been found in many parts of continental Europe, dated to the time before they appeared in Britain. Two important types of beakers appear to have originated in different places , 'Bell Beakers' in Iberia, and 'Corded Ware', in Central and Northern Europe (Bradley 2019, p 150-155). Parker Pearson et al 2019, p.8) suggested that Bell Beakers spread in a complex pattern of flow of directions within continental Europe before arriving in Britain probably from the lower Rhine Valley, one of the closest part of continental Europe to Britain. Beakers may have symbolised group identity among people who shared beliefs and technology. They appear not to have had the same meaning everywhere: in Britain they are almost always found in funerary settings, in Ireland rarely so (Carlin and Bruck 2012). Multiple theories about the making, using, dissemination, and evolution of different types of beakers have been suggested. Parker Pearson, Jay, and Sheridan described many theories that have been propounded to explain the importance of these ceramic objects (2019 pp 2-15).

The fact that it has been difficult to arrive at a single agreed factor makes it attractive to look at single proximate factors. Grupe and colleagues studied the lifetime movement of individuals buried with beakers in Central European countries and found isotopic evidence of relatively small-scale movement from where they spent their early life to where they were buried (Grupe et al 1997).

Factors that have been suggested to explain the role of the ceramic beaker in the move of 'Beaker People' to Britain in the Chalcolithic and Early Bronze Ages	**Author(s) proposing this factor**	**date of publication**
People with specific head shape.	Abercromby	1912
Small groups of metal prospectors from Spain	Childe	1929
Migration of groups from different parts of Europe each with own characteristic form of beaker.	Clark	1970
Single wave of migration from the lower Rhine.	Lanting & Van der Waals	1972
Beakers are 'non-ethnic' signifiers for men, possibly facilitate influential elite beer- drinking cults	Burgess & Shennan	1976
A cultural marker spread by women taking ceramic practices and designs when marrying across cultural boundaries	Brodie	2002

Table 3 Some factors suggested to underlie the movement of 'Beaker People' to Britain, as summarised by Parker Pearson, Jay, and Sheridan(2019, pp 3 to 17)

Sometimes there was evidence of such movement of people in moving together, possibly as in groups (Price et al 2004).

Interestingly, the Beaker People project also found evidence of significant movement within Britain , as well as movement from areas near the English Channel (Parker Pearson et al 435-456). The possibility that movement from the nearby continent at that time was an extension of unexceptional movement within it may be relevant.

The ability to analyse and characterise ancient DNA (aDNA) has led to an application of this to understanding this pattern of movement. Olalde and colleagues (2018) compared aDNA extracted from the remains of 37 people buried with Beakers with that of 51 people from the British Neolithic. The Beaker People were found to be much more likely than the Neolithic sample to have a type of DNA associated with populations from the Pontic Steppes, near the Caspian Sea. The researchers also compared the prevalence of 'Steppe aDNA' among those in the Beaker group where radiocarbon dates spanned at least two centuries. Their modelling of this suggested that Steppe aDNA completely replaced almost all Neolithic aDNA over the course of two centuries. Further analysis suggests that the data imply that only 80% replacement occurred, possibly over 16 generations (Booth, et al 2021). Drawing conclusions about population replacement from these data is problematic because the Neolithic sample used was unlikely to adequately represent Late Neolithic people, given their frequent disposal of bodies using cremation and other methods of disposal , which do not yield aDNA evidence. Nevertheless, the study does show that a significant number of 'Beaker people' who came to Britain carried Steppe genes, and their appearance was associated with the first working of metal, initially copper, then gold, tin, and bronze. Another factor relevant to the possibility of population replacement has been prompted by the finding of the presence of the genes of a bacterium centrally involved in bubonic plague (*Yersinia pestis*) in three skeletons in Cumbria and Somerset which were radiocarbon dated to the period 4300–3700 cal BP (Swali et al 2023). The inadvertent harm caused to populations through exposure to disease to which they had no resistance has been a feature of the movement of peoples from one continent to another, such as the movement of Europeans to North and Central America.

The meaning and process of this significant movement remains to be clarified (Furholt, 2019). The arrival in Britain of a relatively small group of incomers with a clearly separate identity, bringing such novel technology, stimulates questions about issues for the relationship between the immigrant and Indigenous populations. Needham (2005) conducted a detailed analysis of the trends over time of morphology of beakers found in graves, and of objects found with them and suggested that these reflect the societal changes. Initially there was a fairly standard type of beaker, made to a distinctly continental European style. He described these exclusive objects as representing a 'circumscribed exclusive culture', prevalent from 2500BC to 2250 BC. In this period, he suggested, small pioneer groups of Beaker People with clearly defined values and culture, coexisted, possibly warily at a social distance, with the indigenous elite (Needham 2012, 193-210). As time went by the Beaker identity became increasingly attractive to a minority of the elite, who began to share it. He noted a point, from about 2250 BC where the types of beaker became more diverse ('The fission horizon'), as if the old prototype had been abandoned and several types of beaker were part of conventional elite culture ('instituted culture'). Instead of a homogenous pattern, local and regional styles became more apparent. Needham also recognised a subsequent phase, from about 1950 BC to 1700 BC where beakers became poorer in quality, accompanied by fewer artefacts; he referred to this decline as 'past reference'.

The change in this type of ceramic used in graves over eight centuries must have echoed other changes in society. This is relevant to the building of barrows around the then old Neolithic sites. Garwood (2012) suggests that the early burials of Beaker people carried out within sight of, but distant from, Stonehenge indicates acknowledgment but not acceptance of them by the keepers of the culture of the monument. That Beaker People built large numbers of round barrows in visually strategic positions (and, as will be reviewed later, close to Neolithic structures in Dorset such as the Dorset Cursus and bank barrows), suggests that these carried out a similar role to that described by Needham, for beakers. Round barrows also sent signals about their constructors' confidence and claim to respect, and, probably, also to rights to land, and other factors.

1.C.2 First use of metal

Early Beaker graves gave evidence of winning and using metal, specifically copper and gold. Three early Dorset burials referred to in the *Beaker People* study were excavated at Thomas Hardye School in Dorchester by Gardiner et al (2007) and dated to around BC 2320, were buried with copper knives. Although copper tools had advantages over flint, they were soon superseded by the much harder metal, bronze, which was formed by adding arsenic or tin to copper. Recent research suggests that tin was available in valuable quantities from Devon and Cornwall from a century after the Thomas Hardye School burials. The Beaker People may have been particularly drawn to access tin from Cornwall and Devon, as it became apparent that this area was a rich source of this metal that can convert relatively soft copper into much harder and more useful bronze. Williams et al (2023) argued from recent evidence gathered by *Project Ancient Tin* (2024) that "in about 2200 BC Britain and Ireland were the first regions in Europe to completely switch over from copper to harder and more gold-coloured bronze for their tools and weapons, typically with around 10% tin". Vankilde (2016) had argued that the English West Country was one of the two great sources of tin in Europe (the other large one being Erzbirge close to the German- Czech border) and likened the process of turning towards bronze ('Bronzization') to the modern search for valuable substances. The presence of tin in Britain could well have been a major attraction to the incoming Beaker People.

1.C.3 Increasing adoption of solar cosmology

One probable type of discontinuity is in the explanations people held about the world and life, that is, cosmology. One can never know what people fundamentally believed, as this can only be inferred from the surviving physical evidence. Although before 2500 BC people in Britain may have shared cosmological beliefs regarding the sun, it is hard to find evidence of this. One could argue that in Dorset the positioning of the uniquely long cursus on Cranborne Chase (McOmish and Tuck, 2002) references the sun by marking the northern end of the southernmost section ('Gussage Cursus') at a position on Bottle Brush Hill that offers a view of the Winter Solstice sun set sinking into a long barrow on Gussage Hill on the horizon (Green, 2000, p.61). One could argue that in such a carefully constructed structure, built integral to the landscape, this could be intentional.

The cosmological interest in the sun was expressed more clearly in the different forms made possible by the first use of metals. Gold was among the first types of metal to be used in Britain and had features that could be seen as representing the sun. It is shiny, its colour resembles that of the sun, it reflects images, and appears, like the sun, to be imperishable, neither rusting nor decaying. One of the first types of objects made of gold were small round discs, so-called 'sun discs', made from thin sheet gold. Most have been found in Ireland, but examples close to Dorset have been found in Wiltshire at Mere (Woodward and Hunter 2015, pp 208-210), Wilsford -cum-Lake (Woodward and Hunter 2015, pp210-213) , and Monkton Farleigh (now in the Wiltshire Museum) (Figure 8) as well as BancTynddol in west Wales (Timberlake, 2016). The commonly occurring image on them is a cross of vertical and horizontal lines, like images of rays of the sun. This is often interpreted to symbolise the passage of the sun through predictable extremes both daily (dawn, midday, sunset, midnight) and annually (spring equinox, summer solstice, autumn equinox, winter solstice).

Woodward and Hunter (2015) carried out a very detailed review of items found in barrows constructed during the period 2300 BC to 1500 BC, and which had presumably adorned the dead people interred within them. They identified gold items that may have referred to the sun, including lunulae. The remains of a lunula was found in the Tarrant Valley in Dorset in 2014, illustrated in Figure 10 (https://finds.org.uk/database/artefacts/record/id/614240).

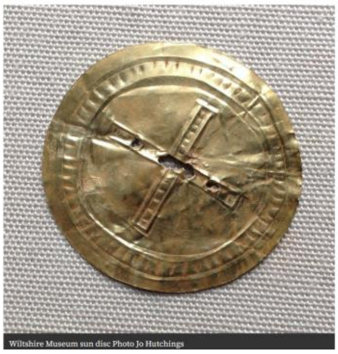

Figure 8: The Monkton Farleigh Sun disc, (depicted by permission of the Wiltshire Museum, Devizes).

Figure 9 A gold lunula found in 2014 in the Tarrant Valley, North Dorset. Image provided by The Portable Antiquities Scheme. Rights Holder: Somerset County Council, License CC BY- SA

Woodward and Hunter examined cones of thin gold that probably covered buttons, such as that from the Wiltshire barrow burial at Upton Lovell (p 222). A similar pair was found in a 'Wessex' barrow at Hengistbury Head in Bournemouth (Bushe Foxe 1915) Figure 11. The Nebra sky disc, a 32cm wide, round bronze object covered in depictions of celestial objects, made from gold (Figure 12), was found in Northern Germany and dated to c. 1800 BC to 1600 BC, (Pasztor 2015), at around the time that the burial in the second largest barrow at High Lea Farm was interred. Metallurgical studies of the

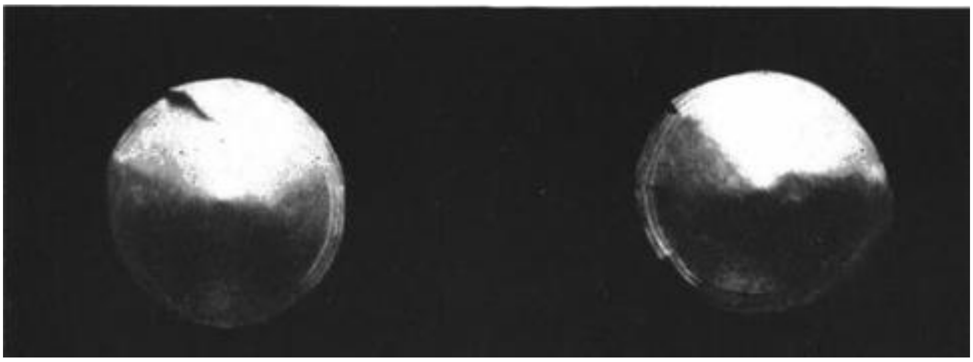

Figure 10 Black and white photograph of two cones of thin gold excavated from a round barrow at Hengistbury Head in 1912 (from Plate 3, Bushe-Fox 1915). Licenced under Attribution 4.0 International (CC BY 4.0).

metals used in decorating the disc found that the gold forming the Sun, the crescent-shaped Moon and the 32 stars attached to the Disc in the first phase most likely came from Cornwall, while the gold at the two arms on the rim came from Romania, and the copper came from the eastern Alps (Ehser et al 2011). This sourcing of metal from such separated places within Europe, demonstrates the links between Britain and other parts of Northern Europe at that time, implying that people in Britain might have been familiar with the ideas of knowledge of beliefs of North European Bronze Age people.

Figure 11: The Nebra sky disc (Vincentz, F., Image licensed under Creative Commons BY-SA 4.0)

Detailed beliefs underlying a sun 'cult' come from students of Northern European images in rock art and engravings on prestigious metal razors, which were given to males as they reached adulthood. Such beliefs are also embodied in the Trundholm Chariot , a model found in Denmark and dated to 1400BC (Figure 13). This is of a horse pulling in a cart a bronze disc, 25 cm in diameter, the disc being dark on one side and gilt on the opposite (National Museum of Denmark 2022) . It is understood to embody a theory of the passage of the sun, that the sun travels in the sky from east to west in the upper world during the day, showing its golden side to the earth. The sun was thought to show the other, dark side, as it travels back left to right at night, through the underworld pulled by an eternal horse.

This reflects a second aspect of Bronze Age Nordic cosmology - of different aspects of reality, with humans operating in the middle world, the sun in the world above, and the dead in the underworld. There were believed to be propitious places and times where the three worlds meet and barriers between them diminish. Kaul interprets the images to mean that humans in the middle world can influence both the sun and the dead, "for example if the dead were honoured by the living in the right way - for instance in cult houses at the burial mound - then the souls of the dead could assist the sun to operate in the best way" (Kaul 2008, p139). Given that sunset was a propitious time, and that the winter solstice sunset was the extreme version of this, it seems that carrying out rituals correctly at a cemetery, such as that at High Lea Farm, at the time of the winter solstice sunset could have been believed be a way in which the living were able to help the dead.

Taken as a whole, these strands suggest that the importance of the sun was shown in golden objects, embodied in objects, and represented in art, using the new materials that became available for the first time in the early second millennium. Given the degree of physical connection between Britain and Northern Europe during that time, and the use of gold objects as grave goods, it is likely that aspects of this belief were known and shared in Britain and , if so , this is an area of profound change from the Neolithic.

1.C.4 Surrounding Neolithic monuments with round barrows.

A third discontinuity between the Neolithic and Chalcolithic and Early Bronze Age lay in the fact that in the latter period round barrows were constructed close to or around Neolithic structures. In some instances, doing this this looks like surrounding them, in others, augmenting them. Doing this could be to show respect for such places, or to limit the power of these sites, or possibly to demonstrate that the new beliefs complemented the old. In any case they marked their recognition of them as being special.

It is striking how often large Neolithic structures became the focus of constructing round barrows. These include the Dorset Cursus (more than 18 barrows: Green 2000); the rare bank barrows built close to the ends of the South Dorset Ridgeway at Little Bredy (8 barrows: McOmish and Tuck, 2000), and at Broadmayne (10 barrows: McOmish and Tuck 2001); the henge complex at Knowlton (187 ring ditches within 1.5 km of the central circle: Stoertz 2007); and a single long barrow on the Purbeck ridge at Ailwood Down (24 barrows).

Figure 12: The Trundholm Sky Chariot: National Museum of Denmark. Permitted under a Creative Commons Attribution-Share Alike 3.0 licence.

The continuity shown by these examples is that some Neolithic monuments continued to be regarded as distinctively different in some way, therefore requiring recognition, incorporation, respect, or control. It could also have been an opportunity for the Beaker People to assert their importance, using round barrows as a symbol and means of change. Alternatively, practical issues might influence this behaviour. One factor could be that there was a demand for building later round barrows at visually strategic locations, from which they would be seen from a greater area, and a Neolithic long barrow was already there. This could be argued for the Ailwood Down group where the round barrows are very visible from the North, but the long barrow less so. Another factor could be that there was pressure for productive land , so new barrows were built in that area already dedicated to the dead.

1.C.5 From large regional Neolithic monuments to smaller local monuments

During the third millennium BC, a notable phenomenon was the construction or elaboration of large ceremonial monuments, often based on henges, which are often interpreted to be regional ceremonial monuments. Examples of these are Durrington Walls, Marden, (both henge enclosures) and Stonehenge (a formative henge), and among those in the study area are Knowlton Rings in East Dorset, and Mount Pleasant by Dorchester (an enclosure henge). Recent application of Bayesian statistical analysis of radiocarbon dates of items found in Wainwright's (1971) excavation of Mount Pleasant found it that was constructed over a relatively short timespan of several generations (Greaney et al 2020). The first of four components of the monument to be constructed was the earthen henge, likely to have been constructed from 2610 to 2495 cal BC. The final fourth dated new component , a ditch surrounding a timber circle which also contained sarsen stones ('site IV') was completed decades after the first appearance of beakers in a grave in England (which was in the period 2435-2325 cal BC: Parker Pearson et al 2019, p.75). Greaney's model indicates that a burning episode and destruction of sarsens in site IV occurred in the region of 200 years after the first appearance of Beaker pottery in England. There could have been benign reasons for this large-scale destruction at site IV at Mount Pleasant, as Greaney et al (p.232) consider . Nevertheless, the closeness in time to the arrival of the Beaker People may instead indicate threat and intimidation.

Some henge enclosures, such as Mount Pleasant, have few round barrows nearby. Others, such as Knowlton, are surrounded by several hundred: Stoertz (2007) identified 178 ring ditches within 1.5km of the central ring. This building or embellishment of such large monuments may have been a defensive response to the potential threats of the incursion of Beaker people. An alternative meaning might be their desire to impress potential visitors or to encourage them to come. Either way, this would imply expectation that visitors might be arriving.

Whatever the cause, the construction of these large structures ceased at around the time of the Beaker incursion, as, presumably, did their functions as ceremonial or religious centres. Some have suggested that their functions were taken over by smaller, more local, centres, such as new round barrow cemeteries (Johnston 2020, p. 248). Other examples, such as Knowlton Rings, seem to have remained as important ceremonial or religious centres for Bronze Age people, but with the profusion of round barrows built around them, but no signs of settlement (Gale and Burrow 2022, p. 120). If the role of regional large centres ceased with the incursion of Beaker People, it is possible that smaller local structures would provide a continuing function, ironically doing so by utilising the smaller groups of burial mounds, an innovation of the Beaker People. The new elite Beaker People may have distrusted large meetings at regional centres, but tolerated small scale, disseminated meetings. Johnston argues that kinship (in a wide sense) is the glue that held Bronze Age society together, and that local groups of barrows provided continuity, and a place to return to for a mobile community, and therefore could be an effective centre for maintaining society.

The above suggestions imply that if there were a conflict of interests between the established inhabitants, and those who had arrived, that there could be only one outcome, like moving away from major henges to find a smaller rural community where they could live more as they wanted. More probably each side had something to give to the other and there may have been some degree of accommodation on both sides, just as implied by Garwood's observation described previously that Beaker graves were built within sight of but not within the Stonehenge monument (2012).

1.D. CONCLUSIONS

The period 2450 – 1600 BC was a time of great change, as shown most clearly in the large-scale building of round barrows , which in itself carried the message of change. The main issue that is particularly relevant to the current study is the notion of these new burial mounds as objects in the landscape. The next chapter will concentrate on this.

Chapter 2 Round barrows as objects in the landscape

2.A INTRODUCTION

This chapter examines the roles of round barrows as objects in the landscape. It first considers an overview of the ways in which barrows have been arranged in the landscape in the study area. Secondly, it discusses research into how barrows have been arranged in the study area and to how the currently existing pattern of barrows might have developed over time. Thirdly, it narrows down to examine how linear arrangements developed and possible explanations for these

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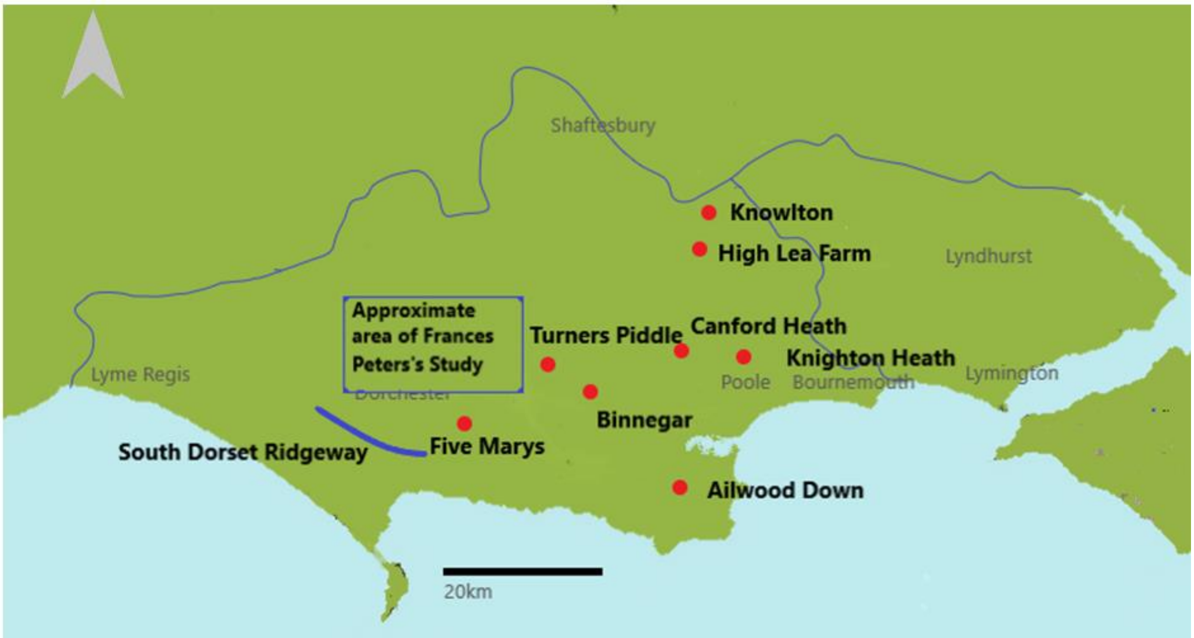

Figure 13: Locations of places referred to in the text of Chapter 2. The study area is the county of Dorset and the New Forest District, indicated by the blue boundary line, (personal collection 2024).

2.B WHAT IS KNOWN ABOUT THE POSITION OF ROUND BARROWS IN THE LANDSCAPE OF THE STUDY AREA?

One way of exploring round barrows as objects in the landscape is to take an overview of patterns of the landscape positioning of all barrows known to have existed in the study area. This is rather like looking at climax ecosystems, such as forests, when they have reached their maximum size, which will be different to earlier versions. Thus, we need to appreciate the patterns of development over time.

Some barrows that once existed have been destroyed without trace, but information about many exists in some form either as physical remains, slight remains visible to LIDAR (Light Detection and Ranging), or soil marks that are sometimes visible from the air. The systematic research of Grinsell (1959, 1982) and five volumes of the Royal Commission on the Historical Monuments of England (RCHME) on Dorset published from 1952 to 1975, documented what was known, and this has recently been complemented by results from Historic England's National Mapping Programme (NMP) of selected areas, based on the systematic application of Aerial Photography and LIDAR. Such studies are complemented by important texts such as those by Ashbee (1960) and Woodward (2000).

Only part of the current study area has been covered by NMP projects, but these do provide a sense of the extent and nature of 'climax' barrow fields. The 7 NMP studies of parts of the study area cover all 566 km²of the New Forest National Park and 1,246 km² (49%) of the total 2,653 km² of Dorset (Figure 15). NMPs have covered important areas of Dorset but not the very significant central Dorset chalk downlands, the northern part of Cranborne Chase, nor the urban area, formerly heathland, in the Southeast. The most complete picture of known locations of barrows, compiled for this study from data available from the HERs of Dorset and Hampshire in the spring of 2024 is presented in Figures 13 and 14. These show a mass of barrows and ring ditches all over the study area with particular concentrations on the chalk lands of the South Dorset Ridgway (SDR) and to the north east of the river Stour.

The six areas studied by the NMP completely covered the whole New Forest, and, parts of Dorset , from west to east: the *Dorset Marshwood Vale* (Fleming and Royall 2017), *Upper Frome and Sydling Valleys* (Fleming 2021), *Dorset South Ridgeway* (Royall 2011), *Wild Purbeck* (Royall 2015), *Lower Stour Valley* (Fleming and Royall 2020) *New Forest* (Trevarthen 2010, Royall 2013). Some summary data from these are included in Table 1. Their conclusions and qualitative remarks are summarised below. The rates of survival of barrows are reviewed in each report and are summarised in Table 1 . These vary by area and are apparently affected by the nature of geology and the, related, intensity of agriculture. The proportion of levelled barrows was found to be higher in the lower agricultural land to the north of the SDR than on the ridges; on chalk land above river valleys flattening north of the Stour; and in the coastal area of the New Forest, but not in the northern hills or central heathland.

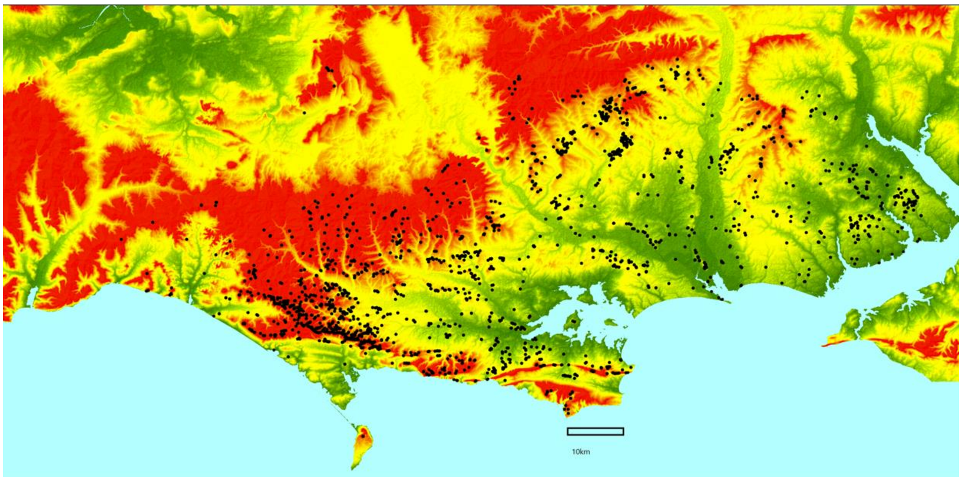

Figure 14 The locations of 3,587 round barrows and ring ditches in the study area. Elevation depicted as green from sea level, yellow from 60m, red from 120m. Details of locations of barrows provided by Historic Environment Records for Dorset and Hampshire, GIS image produced using Terrain 50 data copyright of Ordnance Survey.

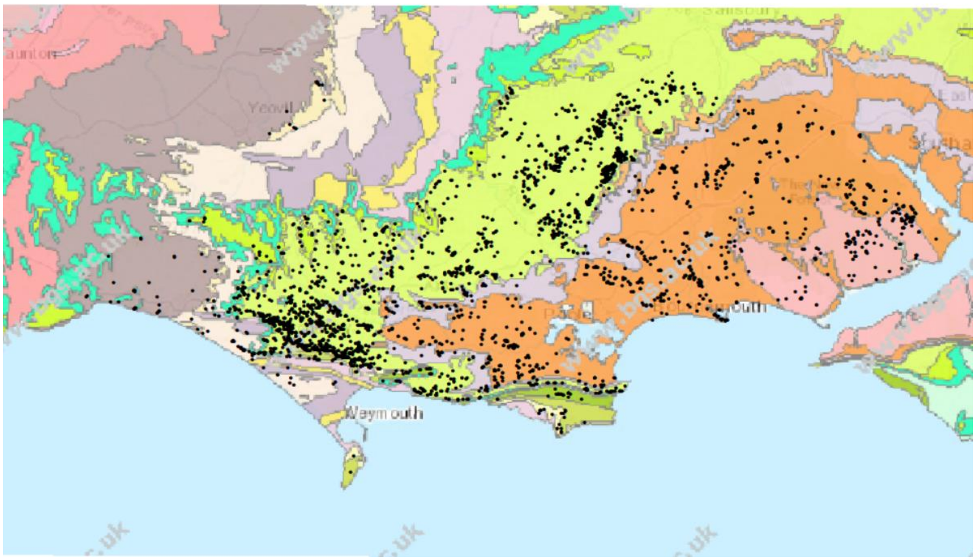

Figure 15 The locations of 3,587 round barrows and ring ditches in areas coded by underlying geology. The light green area signifies chalk geology, orange the mixed clay, silt and gravel that underlies heathland, and lilac, underlying clay. Source of geological data is copyright British Geological Survey . Details of locations of barrows provided by Historic Environment Records for Dorset and Hampshire. GIS image produced using Terrain 50 data copyright of Ordnance Survey .

In the study area as a whole there are two areas with the largest concentrations of barrows, both on chalk geology, but in different circumstances - the area around the South Dorset Ridgeway (SDR), and the valleys of northern tributaries of the River Stour, Rivers Allen, Winterborne, Tarrant, and Gussage. The highest density is close to the SDR, where many barrows occupy visually strategic positions along these eponymous natural, roughly south east-northwest, ridges, and are also present in its lower surroundings. There are significant densities on flatter areas near the eastern edge of the Ridgeway, and on higher ground to the North of the River Frome.
The second NMP area with particularly high concentrations of barrows is the chalk downs around tributaries to the north of the river Stour, such as the rivers Allen and Tarrant. There are many small groups of barrows, but also exceptionally large concentrations in flat areas above the river Allen, such as the Neolithic monumental area of Knowlton.

A third area, Purbeck, is dominated by the chalk-based 10 km long east-west Purbeck ridge, with heathland to its north and an area of mixed geology to its south. Scattered groups of barrows stood on the heathland, particularly on 'islands' of higher ground, and also close to the river Frome, to the north. There is one major group (Ailwood Down) on the Purbeck ridge itself, as well as smaller groups to the eastern end of the hill where it meets the sea. Other distinctive groups in Purbeck stood on chalk on smaller linear ridges such as that to the north above Chaldon Herring (with groups such as 'The Five Marys').

In comparison to these three areas the NMP studies of the smaller areas of Marshwood Vale and valleys of the Sydling and Upper Frome have low densities of rather small barrows, which were relatively isolated, and constructed just below ridges. The investigation of New Forest NMPs has particularly benefited from the use of LIDAR in wooded areas. The New Forest geology is predominantly that of sand and gravel overlain by caps of clay. There were concentrations of barrows in the central heathland, but also in northern hills, and the coastal plain, which has a more complex geology, with significant areas of gravel, and consequent industrial gravel extraction.

These studies show that densities and organisation of barrows varied considerably within the study area. In several rather different types of landscapes many identified barrows tended to be constructed on higher ground such as near the summits of the hills that make up the South Dorset Ridgeway, and areas where slope flattened out in chalkland river valleys such as those of the River Allen or Tarrant. In heathland, they tended to occur on 'islands' of raised ground or above small stream valleys in rolling heathland or forest. This tendency to be on relatively higher ground was observed whether the density of barrows was high or low, and regardless of the scale of the relative height. Constructing barrows below the crests of hills can make them visible from valley bottoms below.

NMP Report Title	area of NMP in km^2	overall density of barrows in each NMP Report Area	no. recorded barrows in each NMP Report Area	% barrows levelled in each NMP Report Area
Marshwood Vale	193	0.1	28	unclear
Upper Frome& Sydling Valleys	100	0.6	56	v low
Dorset South Ridgeway	310	2.8	883	66
Wild Purbeck	346	0.8	277	11
Stour Valley	293	1.5	439	73
New Forest Remembers	400	0.6	226	14
Aggregates Hampshire	173	0.6	112	51

Table 4: Summary data taken from the seven NMP reports of districts within the study area. The column *overall density of barrows in Each NMP Report Area* contains the result of dividing the total number of barrows recorded in a Report (third data column in the table) by the area covered by the Report (expressed in square kilometres in the second column). The result, listed in Column 3, is expressed to the nearest 0.1 (of barrows for each km^2), and is a broad estimate of the overall density of barrows in the area covered by that specific report. As an assessment of the overall density for a specific Report area it tells nothing about the pattern(s) of density within that Report area.

The purpose of this brief summary was to provide an impression of where round barrows were built and to touch on some of the factors influencing this. Some factors reflect the physical nature of the landscape (such as river valleys, underlying geology), some reflect

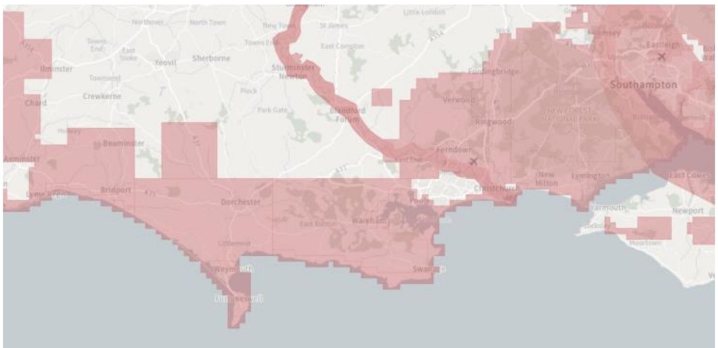

Fig 16: The area of Historic England National Mapping Programmes that cover the research area (is coloured in pink). From https://historicengland.org.uk/research/

the interaction of human activity with the landscape (such as preferentially farming on chalk lands), and some reflect both this interaction and also the physical remains of past human activity, such as the construction of so many round barrows built close to Neolithic monuments, both small and large.

2.C. HOW DID THE CURRENT PATTERN OF BARROWS IN THE LANDSCAPE DEVELOP OVER TIME?

2.C.1 Different types of barrows on different niches on Dorset chalk downs.

Peters (1999) attempted to understand the development of groups of barrows by relating the size and landscape setting of barrows to dates inferred from the results of antiquarian excavations. She studied the 186 round barrows in an area of Central Dorset Chalk downs to the North and East of Dorchester, roughly 20km by 20km (on Figure 12) (this area is not covered in the NMP programme). By examining the size and landscape positions of barrows she arrived at a typology of ‘Conspicuous’ and ‘Non conspicuous’ barrows. The 54 ‘Conspicuous’ barrows were larger (with diameters exceeding 18m) and stood in positions close to but below the tops of eminences in the downs, often on watersheds. ‘Conspicuous’ barrows tended to be visible from a long distance and from a specific portion of the land below. The 132 ‘Inconspicuous’ barrows were smaller (with diameters less than 18m), standing at lower altitudes, and tended to be visible only from a small distance, thus not acting as landmarks.

Inconspicuous barrows tended to contain Deverel Rimbury ceramics (dating from between 1600 BC through 1200BC) while Conspicuous ones often stood alone and contained plainer 'Wessex' ceramics more typical of the early 2nd millennium BC. There were only two radiocarbon dates available, and the attribution of dates was not completely clear. From this Peters argued that the two types of barrows were built by different sets of people with different motives, that smaller barrows were built for less influential farmers, who did not wish to advertise their presence and did not wish to challenge the *status quo*. The pottery found within them tended to be standardised and conservative in design. Household members could solely construct the relatively small barrows. In contrast, she suggested, the builders of the Conspicuous barrows wanted to project their importance and influence towards particular groups of people who lived in places where these structures would be visible. An important finding is that, dating apart, barrows that differed physically were constructed in specifically different niches within the same landscape. Taking account of dating makes it possible to conceive that the people who built the non-Conspicuous barrows were descendants of those who built the Conspicuous barrows. Location, chronology, and the (probably related) density of occupied land, may account for much of the pattern observed by Peters.

2.C.2 Different types of barrows built on Dorset chalkland and heathlands of Dorset and the New Forest

A second approach to the development of barrows over time was Bradley and Fraser's (2010) comparison of round barrows in central Southern England that were either built on chalk or on heathland. They argue that the former were built before the latter, often in places that had already been settled for some time, probably between 2400 to 2100 BC. They note that these were often used, in effect, as cemeteries in which the primary interment was followed by others. Probably, with the passage of time , the amount of land available for new settlements diminished and it was more practical to settle new ones on as yet unused and less fertile land off the chalk. Bradley and Fraser note that heathland barrows tended to be built later (BC 2100 to 1850) in places where none had been built before. They note that heathland barrows were more simply constructed, contained only one set of remains, and few grave goods, and tended not be reopened. They observe that those built on chalk are surrounded by ditches with places to enter and were reused over time: in contrast the heathland barrows were constructed with complete encircling ditches and were not re-used. Bradley and Fraser suggest that heathland barrows were built by people who are new to living in relatively isolated land rather than moving into previously settled communities, and that these smaller barrows were erected singly, not part of a group, and differed from those on chalk in style, and size, as well as the location. This complements Peters's study by looking at distinct groups of people erecting distinct types of barrows in different locales, which were then utilised differently, possibly reflecting changing settlement patterns . Bradley and Fraser's synthesis is wider in scope than Peters's study, but built on a smaller corpus of supporting evidence, referring mainly to the different sets of barrows excavated by the same archaeologists in North Dorset and the New Forest. It is possible that the New Forest was developed after much of the prime chalk agricultural land elsewhere was utilised, possibly resulting in fewer conspicuous barrows in the Forest. The persuasive paper gives a clear theory which should be testable with data in the public domain but contains little and would be stronger with more. The results of both studies contrast different types of barrows built at different times in different niches. While it is likely that the developing pressure for productive land played a role, it is difficult to separate out the effects of these confounded factors, so the results can only be taken as suggestive.

One assumption of this synthesis is that those areas that are heathland now were heathland during the period BC 2100 to BC 1850, and those that are now in open countryside on chalk were the same then. This assumption is supported by the work of French and colleagues, who marshalled evidence that early in the Neolithic much of chalk lands of Dorset etc were open landscapes, fairly free from woodlands (French et al 2003). In contrast, pollen analysis carried out during excavations of round barrows on Dorset heaths found these to have been constructed on what was then established heath. The heathland developed following the deforestation of virgin woodlands of lime and oak that had grown on sandy soil, which resulted in a more acidic soil, often podsolised, that was conducive to the growth of heather. Examples include barrows at Binnegar (Scaife 2011), Canford Heath, Poole (Haskins 1980), Knighton Heath, Poole (Dimbleby 1952), and Turners Puddle Heath (Dimbleby 1953). There are no published parallel studies of barrows in the New Forest . These findings of continuity of chalk and heathland support Bradley and Fraser's argument of a link between differences in the physical environment where barrows were constructed, and the type of barrows built. The observed differences raise questions about the meaning of the trend of constructing smaller communities, with noticeably different funerary customs, in this new niche. The fact that the two types of barrows were built at separate times resembles Peters' study in suggesting that one type of barrow was built later than the other, in different circumstances.

2.C.3 Variations in the structure of barrow groups over time.

Peters's attempt to differentiate the two types of barrows occurring in Central Dorset was hampered by the limited evidence of dating provided by unclear accounts of antiquarian excavators, and also, by using ceramic styles as proxies for dates. Bradley and Fraser's account of differences between chalk and heathland barrows depends on good dating evidence and points to how important dating is in understanding how barrow groups may have evolved in time and space. Unfortunately, they provide little in this article. This issue has been emphasised by Garwood (2007) who argued that, for example, it may be misleading to assume that groupings of barrows visible today, such as those lying on the horizon visible from Stonehenge were initially planned as a group to a plan to convey a particular meaning (Woodward and Woodward 1996). If the assumption of (approximate) contemporaneity is incorrect, and they were built centuries apart, how valid would such an interpretation be ? It might be more interesting to try to understand how the arrangement developed over time.

Garwood (2007) investigated the issue by finding all published examples of well-dated multiphase barrow sites, that is, "sites for which there is high quality dating evidence for the occurrence of two major construction events are directly dated by material in secure contexts , and that at least one of the events was provided with a reliable absolute date" (p32). From this set of 22 sites, he identified a process of development of types of barrow grouping. Chronologically, the earliest round barrows were fairly small and apparently organised randomly, rather like those described by the NMP study of the Marshwood Vale alluded to previously. The next type of arrangement , to occur from 1850 BC till about 1600 BC was that of linear groups of mounds. Garwood's results also described subsequent types of modifications, mainly to convert groups of barrows into places for performance and display, but the development of linear groups is the most important to the focus of the current project.

The strength of Garwood's study derives from its dependence on high quality dating of monuments from a wide variety of English and Welsh sites and its ability to discern a sequence of development, rather than simultaneous random change. This provides a basis for asking and answering more searching questions about usage and possible changing roles of groups of barrows over time. By focussing on groups where change had occurred, rather than those where it hadn't, it emphasised the dynamics of change, rather than why some groups were not changed. His argument is essentially about the patterns of change in barrow groups in which change occurred. It would have been stronger if it had also included appropriate samples of relevant groups in which no change had occurred (and had also been subject to high quality dating).

The finding that the first organised arrangements of barrows were linear has an important implication for the current study. Garwood speculates about the meaning of this, including the observation that some lines were aligned on extreme solar events on the horizon. He conjectured that this could provide a place where rituals could take place in combination with eternal unchanging events to enhance the meaning. His finding that, subsequent to the development of straight lines, changes to groups to barrows often took the form of developing arenas or spaces ideal for performance or display, is also important, since it strengthens the possibility that groups of barrows could have become increasing important as venues for performing ritual and other activities. The hypothesised move of ritual activity from Neolithic regional centres to local settings, such as groups of round barrows, has been discussed in Section 1C5 of Chapter 1.

2.D LINES OF BARROWS

The research discussed above suggests that some of the ways in which types of barrows developed in the landscape, probably reflected a variety of factors of life: some are dramatic (moving from crowded chalk sites to 'greenfield newbuild' sites in heathland) some less so (living inconspicuous lives). The focus of the current project is on linear arrangements of barrows, and the possibility that these are built to point towards annual solar turning points on the horizon. Garwood's finding that linear groups were one of the first types of organisation to develop, and at around 1800BC to 1600BC, provides an interesting context for the second largest barrow in the High Lea Farm Group that was dated to 1948 – 1747 cal BC (Bennett and Gale 2017). Little is known about the prevalence of linear groups, let alone their dates. What about their purpose?

Some general theories about barrow groups and their role in defining place and community and the reproduction of culture, deal with issues that would explain any type of funerary monument. In a sense these are dealing with the role of funerary monuments, including lines of barrows. Barrett (1991) argued that because ritual, particularly funerary ritual, is important in providing people with knowledge about dealing with the key transitions in life, its repetition provides knowledge of how to deal with death and other crises, and thereby plays an important role in reproducing culture. This process could have moved from regional centres to local centres, from large henge enclosures to barrow cemeteries.

At a more specific level of analysis, relational ontological accounts such as those of Johnston (2020) and Bruck (2019) emphasise the importance for a fairly mobile and dispersed population of attachment to people and places, and the key role that funerary monuments play in creating and maintaining community. Johnston (2020, p 11) argues that attachment to people, in the form of 'kinship', a notion that is wider than extended family, is the most important issue in understanding social life in the early 2nd Millennium BC. He suggests that, given the decline of regional or national ritual centres from the Neolithic , relatively small local monuments such as stone rows and groups of barrows may been used to perform the same roles, as places for renewing and extending kinship bonds, with both the living and the dead. He also suggests the value of carrying out rituals at times of eternally recurring celestial events like the solstices, to extend and deepen the meaning of such events and strengthen attachment to living kin and dead kin. Lines of barrows could provide a setting for such rituals. It is relevant to note from a Bayesian analysis of radiocarbon dates of interments within a set of round barrows, the implication that people involved in rituals at barrow groups may have been able to have personal memories of individuals interred within them Garrow et al (2014). This suggests that individuals could attempt to communicate with deities for their dead ancestors at propitious times and places, such as carrying out rituals at graves, at important sunsets.

Bruck (2019, p175) also suggests that lines of barrows could symbolise journeys, pointing out that some are placed in valleys beside rivers, and some are placed on ridges (like the South Dorset Ridgeway) to accompany a pattern of movement.

2E CONCLUSIONS

Round barrows are objects in the landscape and can plausibly have been positioned where they were for one or more functions, to be seen from afar, or from a specific direction, to lay claim to territory, to be closer to heaven as a place for rituals, to provide a view over the dead persons' home, to act as way markers, to stir memories and to pass wayfarers on to the next part of their journey, to be inconspicuous places to carry out rituals etc. The aim of this study is to assess the extent to which lines of round barrows 'point towards' a predictable extreme annual solar event , the winter solstice , occurring on the horizon. This would be unlike the stimulus for this study, High Lea Farm cemetery, which arguably combines such an event as seen from a special place (a cemetery) with seeing it occur over a special place. This study does not test for the possibility that the winter solstice sunset is seen to occur over every such a special place, merely that the trend is there. The study would differ from that of High Lea Farm by having as its focus of analysis the directions of individual lines rather than a group of lines.

And what can be concluded about the short lines of barrows, such as were found at High Lea Farm? The suggestion that these were constructed in a pattern that pointed up to the largest barrow, and beyond that to the position of one fixed point in a changing world, the winter solstice sunset, highlighted against a significant location, is compatible with many of the suggestions here. The date of High Lea Farm's funerary use fits in with the period which Garwood found in that most linear groups were built.

The core of this project is to assess how far other lines of barrows might also point towards the winter solstice sunset. The hypothesis is plausible in the light of what is known about their origin in the time of the 'sun cult' . The issues involved in directly answering this question will be discussed in the next chapter.

Chapter 3 The tasks of Identifying lines of barrows to be included in the Study and also of measuring the extent of declinations of lines.

3.A INTRODUCTION

The broad aim of this research project is to assess the extent to which lines of barrows were oriented towards predictable lunar and solar events on the horizon that occurred during the period of interest. A narrow aim, emerging from the literature reviewed in the Preface and Chapters 1 and Two, is to assess the extent to which lines of barrows were oriented towards the Winter Solstice sunset. Both aims are compatible with one another and use largely the same data set.

This chapter describes two necessary preparatory tasks in answering questions about the directions of lines of barrows . The first of these, in Section 3. B, is identifying a representative sample of lines of round barrows to be studied. The second, in section 3.C, deals with gathering the information from which the important characteristic of declination could be calculated. Understanding these two tasks leads to the next chapter, which describes measuring the declinations of lines of barrows that have been selected for the study.

3.B IDENTIFYING A REPRESENTATIVE SAMPLE OF LINES OF ROUND BARROWS.

Identifying such a sample required using an unbiassed systematic search strategy by (a) defining the research area (b) producing a definition of what would be regarded as a line of round barrows (c) using two separate systematic ways of searching for possible lines.

3.B.1 Defining the research area. The research area chosen was the county of Dorset and the New Forest District. These could be conveniently reached from Bournemouth University and contained a variety of chalk and heathland landscapes.

3.B.2 Producing a definition of 'a line of round barrows'. It is important to produce a reasonable set of criteria to underpin consistent action and reduce bias . The process of doing this started with considering definitions used in other research studies, which had different interests. After considering these and looking at reviewing different lines the main criteria arose and were adopted. The expression 'lines of round barrows' comes not come from *a priori* theorising, but from the recognition that some barrows were built in lines and have been given names like 'The Five Marys' and 'Four Barrow Hill'.

Figure 16: Locations in the study area referred to in the text of Chapter 3. The study area is the county of Dorset and the New Forest District, indicated by the blue boundary line (personal collection 2024).

The key characteristics of such easily recognised lines are that they are more or less linear arrangements (barrows forming a single line) and that their spatial arrangement distinguishes them as a separate entity from nearby barrows. Researchers have defined lines of barrows in ways appropriate for their purposes and have tended to focus on three issues: the straightness of lines, the number of barrows forming lines, and the extent to which they form a distinct grouping, separate from their neighbours. In a different context Fleming (1971, p141) defined 'linear cemeteries' as being linear groups of at least four barrows, each separated from neighbouring barrows by no more than 100m. The 1975 report on Dorset by the Royal Commission on Historical Monuments of England (RCHME) used 'barrow group' to mean 'four or more barrows related to one another by proximity, situation or common relationship with some other feature'(1975, p 422). They noted two subtypes of linear groups , being either straight or irregular lines, and observed that the former tended to be shorter (p. 422). In the current study, with different aims, there seems to be no compelling reason to do the same, and so it accepts lines of three or more barrows. 'Straightness' was not defined more formally than ‘more-or-less straight’. Potential mathematical definitions, such as measuring least-squares regression, run into more problems than they solve. This inclusive approach accepted imperfectly straight lines.

3.B.3 Seven criteria for inclusion in the study.

Criterion 1 *This study focusses on the locations of linear arrangements of round barrows that are known to have existed*. These include (a) the locations of extant barrows, (b) ring ditches, most of which are assumed to be the remains of the ditches of levelled barrows, and (c) barrows that have existed in an identified location but have been destroyed either through excavation or for other reasons. Some excavations of ring ditches, such as those of Parfitt and Hoskins (2017) and of Havard, Darvill, and Alexander (2017), have not found them to encircle a burial and/or a mound, but these are rare findings. It is assumed for this study that, unless there is evidence to the contrary, all ring ditches did encircle a burial and mound . It is assumed that all round barrows were built after 2500 BC unless there is evidence to the contrary.

Criterion 2 *The arrangement should be more or less straight.*

Criterion 3 *Lines should consist of at least 3 barrows.*

Criterion 4 *Lines may be seen both as an individual group of barrows, and also, at a different scale, as part of a larger arrangement*. In Dorset, an example of such a larger arrangement is the South Dorset Ridgeway (studied by Woodward in 1991) which runs along several lengths of ridges for about 10 km in total, and on which are groups of barrows, some of them linear. Such groups can be accepted.

Criterion 5 *The arrangement should be distinct from neighbouring arrangements of barrows,* usually by the members being closer to each other than to ‘neighbours’.

Criterion 6 *Lines that have a neighbouring round barrow (or barrows) close to them are unacceptable.* This changes the group into something other than a line. Examples of this are given in Appendix A2.

Criterion 7 *Lines within larger dense groups are not accepted*, because of the difficulty of discerning independent lines.

3.B.4 Two Methods of identifying Potential Lines of barrows. Two different search methods were used to find potential lines. The first synthesises lines from knowledge of the locations of barrows. The second searches the National Heritage List for England (NHLE) online to find examples in the study area (Historic England, 2024). Possible lines were identified in each search method, and these were compared against the criteria. In order to simplify the work, the two search methods were used one after another: all synthesising was carried out first, and then followed by all the ‘Listing’ (searching the NHLE). Decisions about whether the lines met the criteria were made then.

Method 1: Synthesizing lines was carried out on lists of National Grid References (NGRs) of all known individual round barrows, which had kindly been provided by the staff of Historic Environment Records (HERs) for Dorset and for Hampshire. A total of 3,588 individual NGRs were identified after checking for duplicates and processed. A computer programme was devised to look at all possible lines between all barrows and identify which of those could conceivably meet the study criteria. The logic of the programme is given in Appendix A3. Examples of its use are given in Appendix A4.

Method 2: Searching the NHLE used a systematic strategy, such as “Dorset, lines of round barrows” to generate possible lines of barrows and then select those that appeared to meet the study criteria.

Comparing potential lines against criteria. Potential lines from either source were examined initially by viewing them on an Ordnance Survey map on the *Dorset Explorer* website (Dorset Council, 2024), which could simultaneously display on this map, with controllable degrees of transparency, images of old maps, aerial photographs, sites scheduled by *Historic England* or (in the case of Dorset) recorded by the local HER , and digital images of the landscape such as Digital Surface Models (DSM) . Other sources of LIDAR images (e.g. the online New Forest LIDAR map (New Forest National Park Authority, 2023) were consulted, as were sources such as the RCHME report for Dorset (1975) and Grinsell’s reports (1959, 1982).

Screening produced a list of possible lines, and the researcher compared these ‘possibles’ against the study criteria and arrived at a list of those that appeared to meet them. Fairly lax criteria of straightness were used to initially identify possible lines, but this required much effort in evaluating the output. The computer programme took in lists of NGRs and produced lists of potential lines. The process of synthesising produced 150 potential lines (93 in Dorset and 57 in the New Forest). Of these 52 from Dorset were accepted, as were 13 from the New Forest). The most common reasons for rejection were, in reducing order, lack of linearity, lack of being a distinctive group, and being part of a rather large grouping. The second stage, ‘Listing’, identified 18 new lines in the New Forest, none of which were accepted, and identified 13 new lines in Dorset, of which 8 were accepted. Of 181 potential lines considered, 73 were accepted, and 108 were rejected.

3.B.5 The success of the two screening methods

The researcher joined the University in January 2001, assuming that he would study lines by surveying them. Sadly, the pandemic laws made this illegal to do so, and therefore he used an alternative methodology. Once travel restrictions were lifted it became possible to visit sites: the author did so, and in doing so he found that 2 lines of barrows had difficulties that should not let him continue with them in the project, and so the study went on with a total of 71 lines of barrows. The characteristics of these 71 are listed in Appendix A1 and the reasons for discontinuing 2 lines are listed in Appendix A7.

3.C PREPARING DATA WITH WHICH TO CALCULATE DECLINATIONS OF LINES OF BARROWS.

Declinations are a form of direction, which depend on core measures of direction. There are three important types of core measures of direction, based on measuring the direction of North. 'True North' refers to the direction towards the geographic North Pole. 'Grid North' refers to the direction northward along whichever mapping system one uses. The current dissertation uses the British Ordnance Survey (OS) system. Grid North is marked on blue lines on Ordnance Survey maps. 'Magnetic North' is the direction in which the needle of a magnetic compass points towards. 'North', as measured in each system, varies over time. Magnetic north moves more rapidly than the other types, being affected by large geological events, such as the movement of magnetic iron in the earth's core.

The three measures have recently become almost identical when viewed in Southern Britain: this first occurred in the village of Langton Matravers in Dorset in November 2022 (https://www.bournemouthecho.co.uk/news/23098538.three-norths-meet-first-time-ever-langton-matravers/) and the agreement will reach Scotland in 2024 (British Geological Society https://www.bgs.ac.uk/news/the-great-north-run/). Exact information about the variation of the magnetic North from True North in specific locations is accessible online from sites such as the International Geomagnetic Reference Field (https://geomag. bgs.ac.uk/ data_service /models_ compass/ igrf_calc.html). The British Geological Society provides local advice, such as the angle between grid north (British National Grid) and magnetic north at a given location *(https: bgs. ac.uk*

/data_service/models_compass/gma_calc.html). Magnetic North can also be affected by local geological factors. Section A6D of Appendix A6 of this dissertation refers to information on how to minimise error due to local factors when using a magnetic compass. Measuring direction between two points in both directions using a magnetic compass may provide evidence for local variations.

The short-term changes in magnetic fields should not be confused with the long-term changes in magnetic fields which sometimes reverse completely: the last time this occurred was c 750,000 years ago. (British Geological Survey 2024). More useful to archaeologists are the ‘resets’ of the magnetic fields of pieces clay which contains iron. Exposure to high temperatures, above 570° Centigrade ,such as in fire, can cause a loss of a loss of magnetic ordering, so that the cooling material takes on the earth's ambient magnetic fields , effectively remagnetising them (2021 Physics World). Such effects were found to be useful in a identifying locations on Exmoor where hunter gatherers had used fire (Gardiner, 2005).

Although azimuths (measured as degrees clockwise from North) are important measures of direction, their meaning and utility are limited, because they are specific to their location. The notion of ‘declination’ conveys the meaning of direction but is much more useful because it is not limited to where the observer measures azimuth, thus allowing the examination of sets of declinations to general conclusions. This nature of declination and how to measure it are described in Appendix A6. The next step was preparing data in order to calculate declinations of each line, and this is the focus of the rest of this chapter.

3.C.1 Calculating the declinations of each line The declination of an event seen on the horizon can be calculated from knowledge of the position (e.g. in latitude and longitude) from which a person observes the event, the azimuth (degrees clockwise from north) of the event as seen on the horizon, and the angular altitude of the event (i.e. above or below the plane running horizontally through the observer’s eyes). Declination is location free, that is, unlike azimuth, observations of the identical event from very different locations will have the same value of declination. The notion and utility of declination are described in Appendix A6.

In this study the directions of a line of barrows are taken to be that of an imaginary line that runs between the central points of the two extreme barrows (Figure 19). This may not be perfect, but no other option appears to be universally better. The study defines ‘observing points’ as those on the imaginary line that extends through and beyond these two extreme barrows and are each at 25m distant from the outside edge of each barrow (Figure 20). This places an observer on the notional line that runs through the set of barrows to the point where the furthest barrow away from them ‘touches’ the horizon.

Figure 17: A set of 4 barrows forming an imperfect line (personal collection 2024).

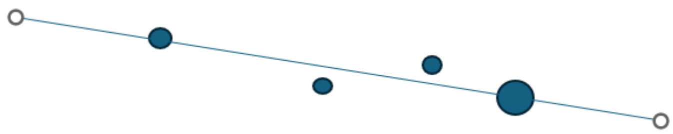

Figure 18: A line drawn through and beyond the two extreme barrows.with observation points (personal collection 2024).

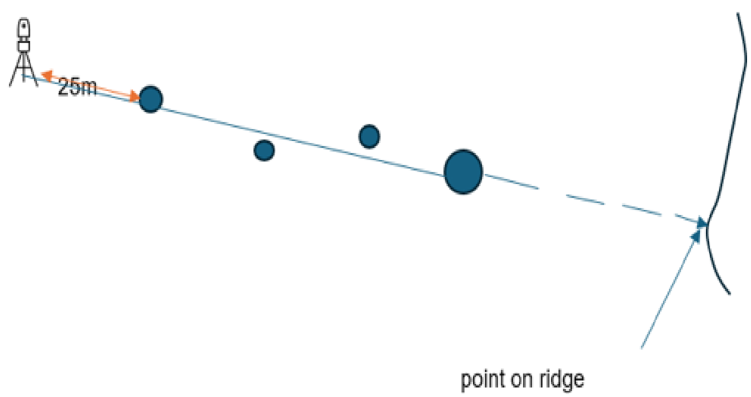

Figure 19: A line of barrows with a central line (between and beyond the end barrows), an observation point on the line 25m from the westernmost barrow , and the point to be observed on a ridge (above the furthermost barrow from the observer) (personal collection 2024).

Measuring the azimuth of that point on the horizon, and its angle above or below the horizontal, and combining these data together with the exact position of the observer, provides sufficient information to calculate the value of declination. This process is illustrated in Figures 17, 18,, and 19. Details about measuring azimuths and angular altitudes using surveying equipment to measure these two values are provided in Appendix A6.

The azimuths of the line are in this study measured between the centres of the two end barrows points. In Figure 19 an observer is placed on the notional line between the two end barrows, extended by 25m to the west. From this point the observer can measure the azimuth and angular altitude to the top of the ridge in line with the eastern barrow.

Taking direct measurements from predesignated standard observation spots on the imaginary line along and beyond the barrows is a standard procedure, but the researcher needed to adopt a computer-based method which generates a model of the horizon visible from any nominated spot. This *Horizon* programme (Smith 2020), utilises Ordnance Survey NGRs or other suitable data to build the horizon. The programme creates a bare horizon of the 360° view from a defined observation spot, either as TIFF image, or as 3,600 sets of data each relating to 0.1°of azimuth in the 360 degrees complete horizon. The data for each point include values of the angular altitude, and of the corresponding declination.

Using *Horizon* in this application involved identifying two observation spots exactly, each 25m out from the furthest edge of an end barrow, along the line that runs through and beyond the central points of the two extreme values. *Horizon* can create a 360° view of the horizon potentially visible from each observation spot. The azimuth between each observation spot and the point on the horizon behind the barrow furthest from it can be read from the output. Azimuths between two points could be calculated using a worksheet provided by the Ordnance Survey (Ordnance Survey 2013).

3.C.2 An example of calculating the declinations of a line of barrows

As an example, consider Figures 20 and 21, which depict a line of four barrows approximately 300 m south of the Dibden Purlieu Inclosure in heathland on the eastern part of Beaulieu Heath in the New Forest (Line G25 in Appendix A1).

A line was drawn between and beyond the centres of the outside barrows, and observation points were identified on that line, 25m beyond the edge of the barrows at each end of the line (Figure 21). The azimuth of the line from the western observation point towards the easternmost barrow is 11.6°.

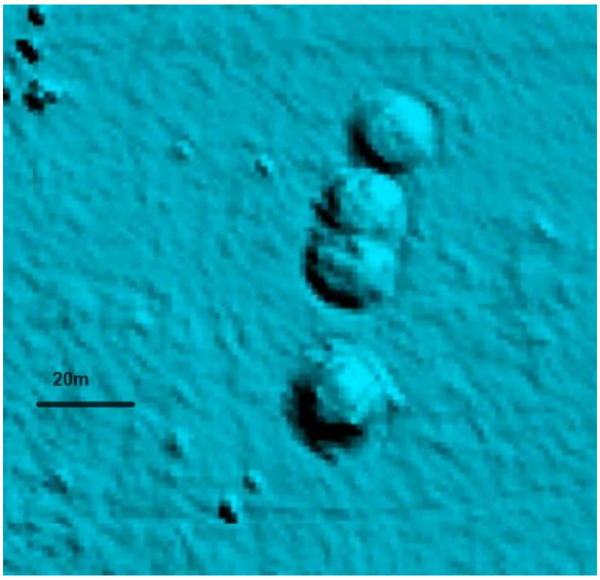

Figure 20: A digital surface model (DSM) of a line of four barrows, *c* 300m south of Dibden Purlieu Inclosure in heathland of the New Forest . This image was produced by Dorset Explorer (2004) and used an image of Tinted Shaded Relief 2m resolution model from the Aerial Photography for Great Britain (APGB). It also it displays copyright material of Getmapping Plc and Bluesky International 2024.

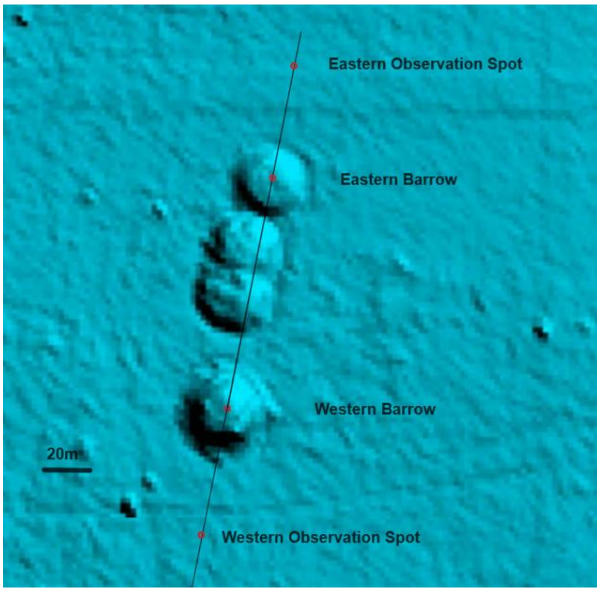

Figure 21 The line between the centres of the two extreme barrows and the Observation Spots 25m out from the extreme barrows (illustrated on a DSM). This image was produced by Dorset Explorer (2004) and used an image of Tinted Shaded Relief 2m

resolution model from the Aerial Photography for Great Britain (APGB). It also it displays copyright material of Getmapping Plc and Bluesky International 2024

A model of the bare horizon as seen from the westernmost point was computed by entering the NGR of the western spot into Horizon. From the western observer the value of declination of the west- east line to the horizon beyond the eastern barrow, as computed by *Horizon* is + 37.8° . That for the reverse is -38.6°. An image of part of the horizon , covering the sector of the horizon around a direction of 11.6° as seen from the western observation point, is illustrated in Figure 22, and a photograph of the view from near to the south east of the western barrow, is Figure 23**.** Using a computer to calculate the image of the bare horizon is an effective substitute for direct measurement, and appropriate for calculating the declination from the observation spot to a point on the horizon. Calculating the azimuth of the horizon where the imaginary line 'touches' it can produce the values of altitude and declination from the 'Horizon' output for that line. Such a system could be used in the case of individual lines of barrows, such as line G25, described above.

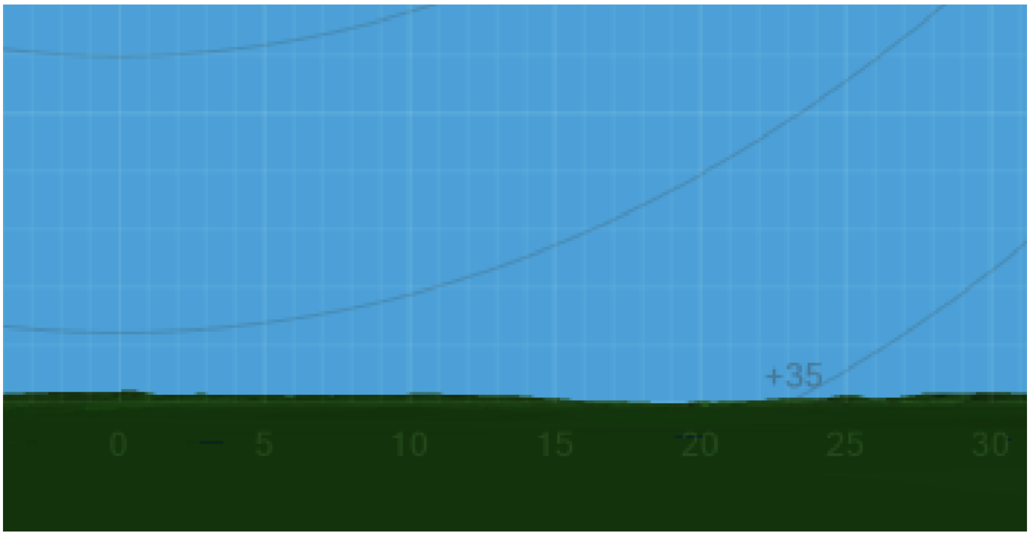

Figure 22 An image of the horizon around an azimuth of 11.6 °, as seen from the western observation point (for the four barrows in Fig 21) produced by the 'Horizon' programme, using Terrain50 data, copyright of Ordnance Survey.

This example (Figure 23) shows that bare model of the horizon may not be that seen by visiting the site. In this example the trees visible are c 400 m away, obscuring what might be seen beyond them.

Figure 23 A view towards the horizon taken from c.20m to the east of the western observation point depicted in Figure 22 (personal collection).

This very basic case study approach will be used in the next chapter (Chapter 4) to assess the prevalence towards the Winter Solstice in the 71 lines of orientations. The following chapter (Chapter 5) describes the analysis of the group of lines of barrows all together, to see whether they have significant directions in common. This requires the use of powerful and sophisticated software specially designed for this task . Although the computation is more complex because it analyses a group of data rather than individual lines, it depends on the same types of data as in the case study above: azimuths of lines, and angular altitudes of points on the horizon (or the data needed to calculate these).

3.D CONCLUSIONS

Using a computer to calculate the image of the bare horizon is an effective substitute for direct measurement, and appropriate for calculating the declination from the observation spot to a point on the horizon. Calculating the azimuth of the horizon where the imaginary line ‘touches’ it can produce the values of altitude and declination from the ‘Horizon’ output for that line. Such a system could be used in the case of individual lines of barrows, such as line G25, described above. This very basic case study approach will be used in the next chapter (Chapter 4) to assess the prevalence of lines towards the Winter Solstice in the 71 lines of orientations. The following chapter (Chapter 5) describes the analysis of the group of lines of barrows all together, to see whether they have significant directions in common. This requires the use of powerful and sophisticated software specially designed for this task . Although the computation is more complex because it analyses a group of data rather than individual lines, it depends on the same types of data as in the case study above: azimuths of lines, and angular altitudes of points on the horizon (or the data needed to calculate these).

CHAPTER 4 The prevalence of lines of barrows sharing the declination of the Winter Solstice Sunset in 2000BC .

4.A INTRODUCTION

This chapter assesses the prevalence of lines of barrows sharing their declination with that of the Winter Solstice Sunset in 2000 BC. This simple study examines how common this pattern is, given the case for doing so formed by the Preface and Chapters 1 and 2, and uses the method described, with an example, in Chapter 3. The three lines of barrows at High Lea Farm, one of which was oriented towards the Winter Solstice Sunset in 2000BC, did not take part in this study.

4.B METHOD

4.B.1 Identifying observation points. For each of the 71 sets of barrows the positions of two notional observation spots were calculated on the imaginary line between and beyond the two extreme barrows of the set.

4.B.2 Computing azimuths. The azimuth between each observation point and the centre of the barrow at the opposite end of the line was computed , using NGRs of each of these points line of barrows.

4.B.3 Calculating the horizon potentially visible from observation points. The horizon potentially visible from each of the two observation points for each line, was calculated for each of the 71 lines of barrows, using Smith's (2020) *Horizon* programme.

4.B.4 Looking up values of declination of lines. The output from each Horizon calculation produced the value of declination for the line from the observing position, in the direction of the line. Views from western observation points gave the values of declinations for where the sun rose above the eastern horizon, that from the eastern points for where it set over the western horizon.

4.B.5 Comparison of the calculated declination of lines with that of the Winter Solstice Sunset in 2000BC. The value for 2000BC was -23.95° (Ruggles 1999 p.57). Lines with declinations within 1.5° of this are regarded here as a 'hit'.

4. C. RESULTS

Of the 71 lines studied two pointed closely towards the Winter Solstice sunset of

2000 BC. The values of declination computed for the nearest three lines were, for Black Hill, -23.98°; for Badbury Rings, -22.43°; and for Handley Hill, -21.74°. The values of declination from westernmost barrows of these lines were also computed. Only that for the line at Badbury Rings (at + 23.3°) was close to that of the Summer Solstice sunrise in 2000BC. Observers at the Black Hill line (with a declination of 29.8°) could have observed the North Lunar Major moonrise (at +29.95°, Ruggles 1999, p57).

Figure 24 A line of three barrows at Badbury Rings, Pamphill, Dorset. (personal collection).

4.D. COMMENTS

The prevalence of lines oriented towards the Winter Solstice is low (2 of 71 is 2.8%) . Most lines of barrows studied were not oriented towards where the annual Winter Solstice sunset occurred on the horizon. Of the two that did so, one , Badbury Rings, was constructed in an area with a high density of round barrows and findings from the Bronze Age, some of which are summarised in section P3. The striking block of sandstone decorated with inscribed images of metal axes and knives, found in a barrow close to the Badbury Rings (Figure 7) is one of only two depictions of both types of metal weapon together in Britain, the other being at Stonehenge (Garrow and Wilkin 2022, p. 195).

Recent excavations very close to Badbury carried out by Papworth (2022) found flintwork that was typical of the Upper Palaeolithic, the Neolithic, and Early Bronze Age, as well as Iron Age pottery. The construction of an Iron Age hillfort ('Badbury Rings') and that of the Roman road that passes about 20m from the three barrows, illustrate the persistent importance of this area over time.

As Papworth suggests (2022, p145) the repeated use of this area over several millennia may reflect its strategic position, of relatively high hills providing views of the surrounding landscape, and acting as a landmark, linking the area with significant areas such as the Mendips, Salisbury Plain, and what has become the Dorchester area. Building a line of barrows that points towards both the winter solstice sunset and the summer solstice sunrise is rare and suggests that this was a very significant place during the period of interest.

The site of the Black Hill line of barrows is similar in being on a gentle slope on the SW side of the eponymous hill, with far-reaching views towards the south-west , some 15 km distant. There are six other round barrows within a km of the line, all on the top of the hill.

The method employed here is a traditional one but may be limited by the fact that the error of the measurement is unknown, and so the researcher pragmatically took a range of +/- 1.5°, for which there is no mathematical basis. Skyscape specialists have come to accept that all measures have error and have come to view them as probabilistic.   In order to improve on the basic method of calculation used above, specialists such as Silva (2020) have argued that further applications should be based on a probabilistic understanding of data, which should be at the heart of the software to be used . The next Chapter describes the larger second study which uses such a method.

CHAPTER 5

The second study: seeking to discover whether lines of round barrows are significantly oriented in any particular direction.

5.A INTRODUCTION TO THE SECOND STUDY

The second study has a more open aim than the first, to discover whether any lines of round barrows are significantly oriented in any particular direction.

5.B THE GOAL OF THE SECOND STUDY

The aim of the second study : to discover whether lines of round barrows are significantly often oriented in any particular direction.

This attempts to answer a different kind of question from that asked by the first study. Rather than focussing on a specific value of each individual line to see if it is close to a particular value, it is concerned with the properties of a group as a whole, exploring whatever direction might emerge. If a direction were to emerge it would be necessary to consider the possibility that it was consistent with a celestial target or, indeed, some other factor. This process of searching for any recurring declinations of a group of lines has been characterised as 'following the data' rather than testing an hypothesis. Ruggles (2015, p 420) suggested that, in theory, "it should be possible to recognise significant accumulations of probability, note the declinations where they occur, and on that basis identify the astronomical phenomena to which they are most likely to relate". In addition, statistical approaches looking at such accumulations have come to conceptualise those as containing some data and some error, hence the rise of methods such as giving more weight to those in 'humps' of data. Silva has proposed a probabilistic way of thinking about these issues and produced a means of analysing data using this approach (2020).

The group of lines of barrows identified in the first study is subjected to an analysis of the group as a whole to identify whether there are any areas of declination that stand out as a whole and cannot be accounted for by chance. The consideration of the 'hits' in Study 1 is a more primitive approach because it concerns predefined 'targets' rather than observing, 'significant accumulations of probability' at particular aspects of the horizon.

The method of analysis used in this study was developed by Silva (2020) in response to the traditional method of analysis, observing *significant accumulations of probability* . Silva pointed out weaknesses in that and from these developed a new method of analysis embodied in his *skyscapeR* programme (2021).

5.C THE METHODOLOGY OF THE SECOND STUDY

5.C.1 The input required for the programme.

To apply the skyscapeR programme the user loads in (in the case of lines of barrows) information which defines each line, as seen from an observer at a fixed point at one end of the line, and then again from a point beyond the other end of the line. This information is the location of the observer (in latitude, longitude, and elevation of the observing point) and the direction (westward or eastward) along the barrow along which the observer observes. The other data are the values of angular altitude corresponding to each of the 3600 points 0.1° of azimuth apart, as seen from the observation position. Each set of pairs of azimuth and altitude combined together produces what is in effect is a map of the horizon as seen from the observer's spot. If the user knows the type of uncertainty pertaining to the values of azimuth, this can be imported into the programme to improve the results.

5.C.2 The output from the programme

The output is a graph of levels ('densities') of declination along a horizontal scale of values of declination, together with an indication of the probability that the pattern depicted would occur if it was entirely due to random factors (the overall probability). The programme can also indicate local areas of the graph which would be unlikely to occur if the graph was caused just by randomness alone.

5.C.3 The logic of the programme

The logic was developed from two processes described by Silva (2020). The main assumption is that all measurements include error and that a number of measurements cohere into a particular pattern, so that the process of measurement is better understood as probabilistic rather than of discrete individual elements of correct data. Because horizons (altitude mapped against azimuth) are often far from smooth, Silva reasoned that the production of accurate declination data would require a process of coordinate-transformation, involving transforming every measurement of azimuth and altitude on the fly into a value of declination. This is the execution of Silva's second point in his 2020 paper is that "in order to assess the likelihood of celestial alignments such a distribution needs to be coordinate-transformed" . Aggregating the results of this process produces a graphical distribution of levels of density of declination across a horizontal scale of declination, as mentioned above.

5.D THE RESULTS OF THE SECOND STUDY

The data for 71 lines were entered into and analysed by the skyscapeR programme. Firstly, a graph of the distribution of the values of azimuth of the lines was produced across the 360° values of azimuth (Figure 25). This shows an uneven spread of peaks of azimuth, with peaks near 130° and 315°, south-east and north-west. There are less distinct peaks around This is difficult to interpret, given the localised nature of the information (see Appendix A6 for a discussion of 'azimuth' and 'declination').

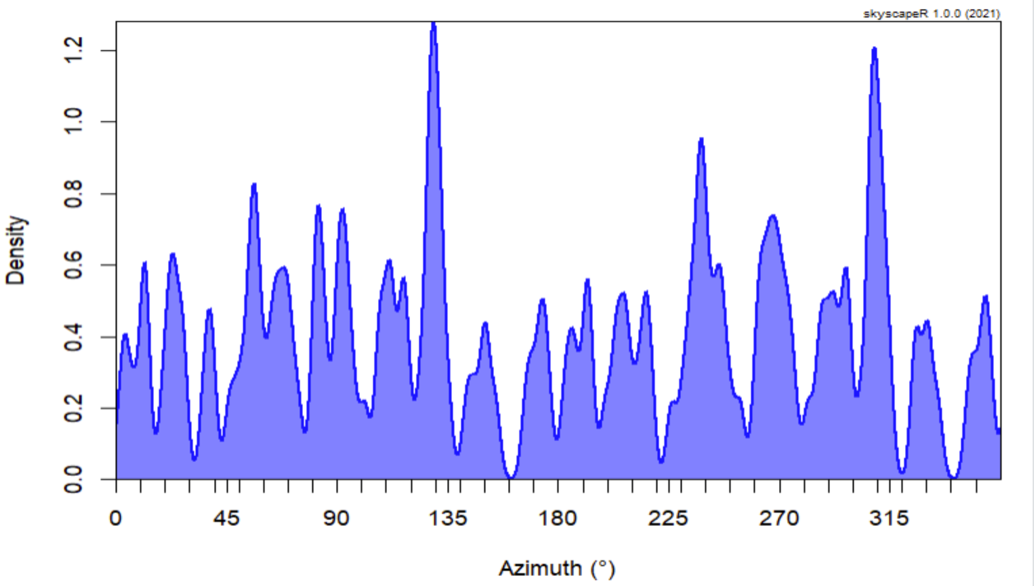

Figure 25 The distribution of values of azimuth for all lines combined (personal collection 2024).

Figure 25 represents the pattern of azimuth produced by analysis of the group of data as a whole, showing the pattern in terms of density in a continuous pattern. Figure 26 represents the values of azimuth for the set of individual lines for each direction. The diagram shows the azimuths of each line in two directions (west-east and east- west). More information on this can be found in Appendix 10. Both representations of the same underlying data show faint clumps at around 130° and 315°, and possibly, 310° and 130°.

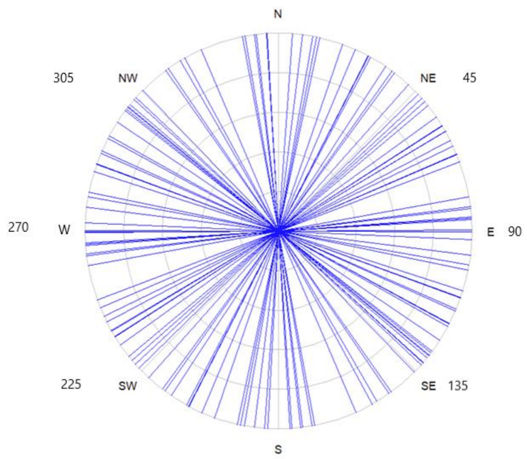

Figure 26 A polar diagram of values of azimuth for all lines analysed individually (personal collection 2024).

The data were analysed to produce a pattern of densities of declination (Figure 27), and then a graph (Figure 28) which also includes, in grey, the pattern of randomness which would be expected in this context. Areas of non-overlap indicate that these are unlikely to be due to chance. The 'global value' of 0.49 on Figure 27, indicates that the overall pattern of declination does not depart significantly from the overall pattern expected by chance alone. Therefore, the local indications of non-overlap depicted in Figure 28 (coloured elements on the x-axis) should be ignored.

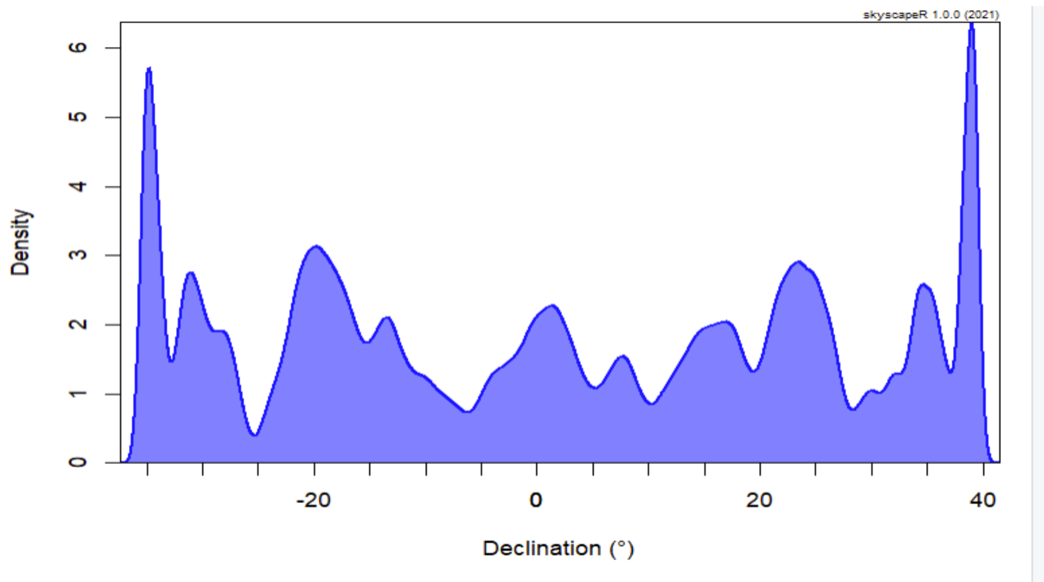

Figure 27 The distribution of values of declination for all lines combined (personal collection 2024).

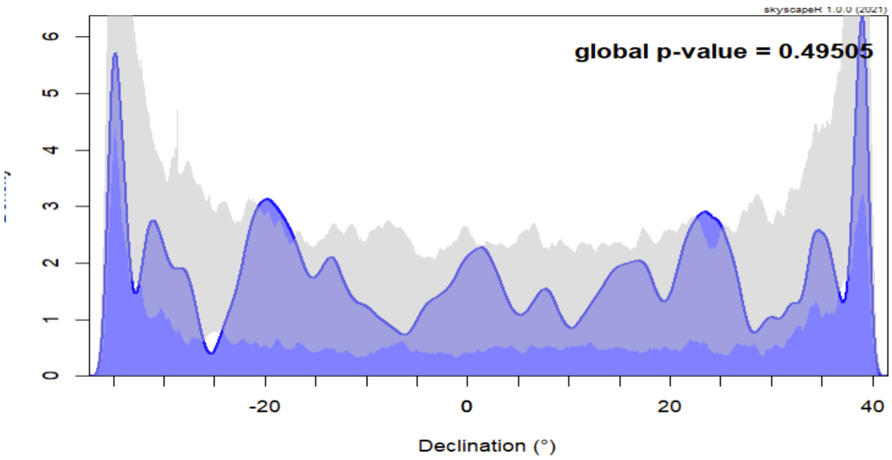

Figure 28 The distribution of values of azimuth for all lines combined is shown against a grey depiction of the distribution of randomness in this context (personal collection 2024).

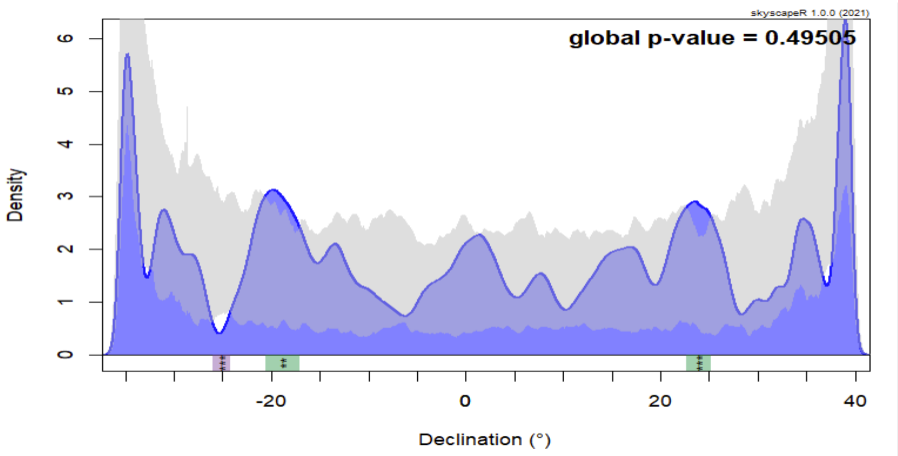

Figure 29 The distribution of values of declination against a background of randomness: the mark in purple on the x-axis indicates a local difference at P<0.01 level). In each case the calculation produced a nonsignificant global probability, not indicating a departure from randomness (personal collection 2024).

The overall analysis of these data found that they are not statistically significant. Therefore, the coloured areas in Figure 28 can only be of faint interest, indicating ranges of values of declination between -21.44° and -17.42° (p-value: < 0.01), consistent with the declination of the southern minor lunar extreme (-18.6°). That between 23.56°, and 25.11° (p-value<0.05), includes that of the summer solstice declination value of (23.9°). Both these ‘ target’ values indicate the declinations of these events between 1500 BC and 2500BC .

5.E BRIEF CONCLUSION REGARDING THE SECOND STUDY

The overall probabilities produced do not support any suggestion that the overall pattern differed from that due entirely to random factors.

CHAPTER 6

THIRD STUDY: A set of East-West lines of barrows in a specific area of Dorset

6.A Introduction.

This brief chapter notes an interesting group of eight lines of barrows in a specific part of Dorset which are all aligned close to the east-west direction. It does not suggest that this pattern of alignment is necessarily a celestial one, but notes this local pattern is obvious and not identified by the overall analysis. It is interesting that lines oriented towards the east and west were found in this study and even more interesting that they occurred in a defined small part of the study area in Southern Dorset (Figures 29, 30) . The notion that prehistoric structures were built to embody east-west directions has stimulated much discussion and raised fundamental issues about whether skyscape archaeologists should ever start from astronomical notions such as the nature of the equinox.

Figure 30 Locations in the study area referred to in the text of Chapter 6. The study area is the county of Dorset and the New Forest District, indicated by continuous green area (personal collection 2024).

6.B The barrows oriented close to the East-West direction
Among the 71 lines of barrows in this study, eight have at least one measure of declination of less than 3° from zero and four have at least one measure of declination of less than 1° from zero. Their locations are depicted in Figures 29 and 30 and relevant characteristics are summarised in Table 2.

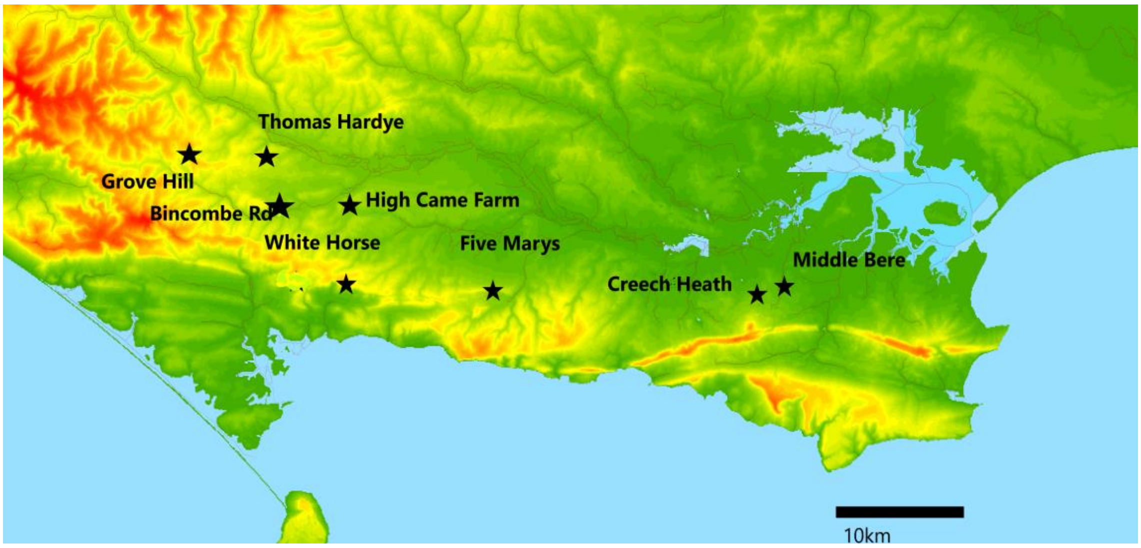

Figure 31 The locations of the nine lines of barrows in south-east Dorset which had a West-East orientation. Elevation is depicted as green from sea level, yellow from 60m, red from 120m. Details of locations of barrows provided by Historic Environment Records for Dorset. Image produced from ArcGIS using Terrain 50 data copyrighted by Ordnance Survey.

The locations of these lines are displayed in Figure 30 and are only found in Southern Dorset, south of the River Frome. A glance at a relief map shows that this area is rich in West East hills, such as the Purbeck Ridge. The higher six are on chalk: the lower two are on bedrocks of clay and sand, typical of heathland. Significant rivers (principally the Frome) flow from West to East, from near Dorchester to Poole harbour.

Group Title	WB	EB	Geology	Elevation	No. barrows
High Came Farm , North of G39	+4.6°	-2.4°	Chalk	98m	5
Creech Heath group G21	+7.0°	-2.6°	Clay	47m	3
Bincombe Down, road G10	-0.5°	+2.9°	Chalk	92m	4
Five Marys G29	-2.7°	+2.6°	Chalk	96m	6
Grove Hill G35	+3.2°	-2.6°	Chalk	113m	4
Middlebere Heath G46	-0.5°	+0.7°	Sand	33m	3
Thomas Hardye G63	-0.7°	0.0°	Chalk	88m	4
White Horse, ridge above G69	-0.5°	-0.2°	Chalk	147m	4

Note. The *G* number refers to the information about the line of barrows of that number in Appendix 1. *WB* refers to the declination along the line of barrows to the horizon as viewed from the West Observation Point. *EB* refers to the declination along the line of barrows to the horizon as viewed from the East Observation Point. *Geology* refers to underlying geology (from the British Geological Survey), *No. barrows* refers to the number of barrows in the line.

Table 5 The values of declination and selected characteristics of lines of barrows oriented in the East-West direction

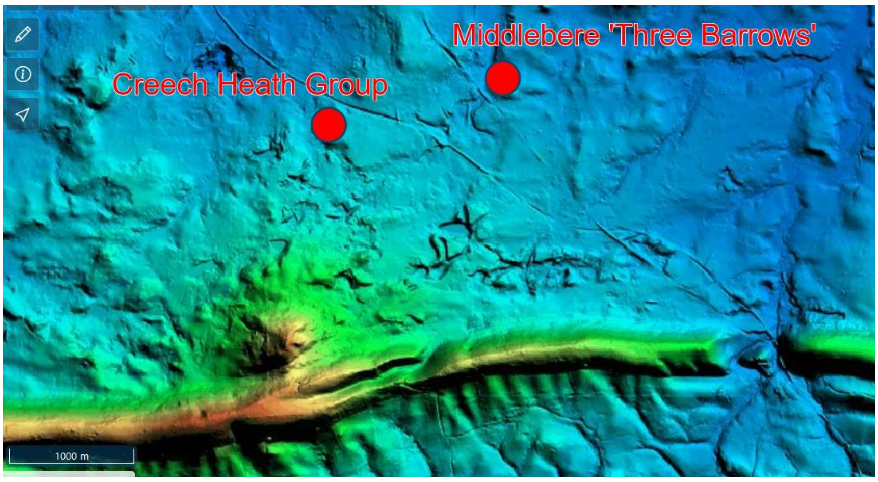

Figure 32 The Creech Heath Group and Middlebere Heath 'Three Barrows' G21 and G46 respectively, in Appendix 1. (depicted on a relief map where blue is lower ground and green and orange higher). *The map comes from Dorset Explorer (Dorset Council 2024), and the DSM from that enjoys Crown copyright and database rights 2024 for*

Ordnance Survey AC0000830671 with additional copyright for Getmapping PLC and Bluesky 2024.

The two east-west lines of barrows constructed on heathlands (Middlebere Heath and Creech Heath) have a visual backdrop of sections of east- to- west Purbeck hills.

Figure 33 A view to the south from the east-west line of barrows on Middlebere Heath , showing an aspect of the east-west Purbeck Hill (personal collection).

Some groups, such as 'The Five Marys' (north of Chaldon Herring), and that on Bincombe Down , occupy visually dominant positions, as seen from lower ground .

Figure 34 A view of the 'Five Marys' group, arranged in an East-West line along a narrow hill, taken from the South. (Attribution (CC BY 2.0) to Stoutcob. https://www. flickr.com/photos/water_mint/16124867149)

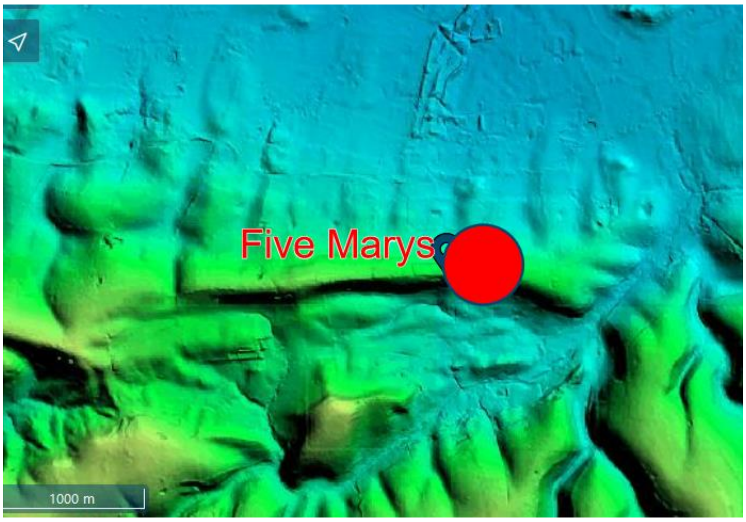

Figure 35 A DSM depicting the context of The Five Marys group on an East-West hill (depicted in green) to the north of Chaldon Herring, G29 in Appendix 1, (depicted on a relief map where blue is lower ground and green and orange higher). *The map comes from Dorset Explorer (Dorset Council 2024), and the DSM from that enjoys Crown copyright and database rights 2024 for Ordnance Survey AC0000830671 with additional copyright for Getmapping PLC and Bluesky 2024,*

The Five Marys barrow group is visible on the heathland to the north and from the valley and hill to the south (Figure 33).

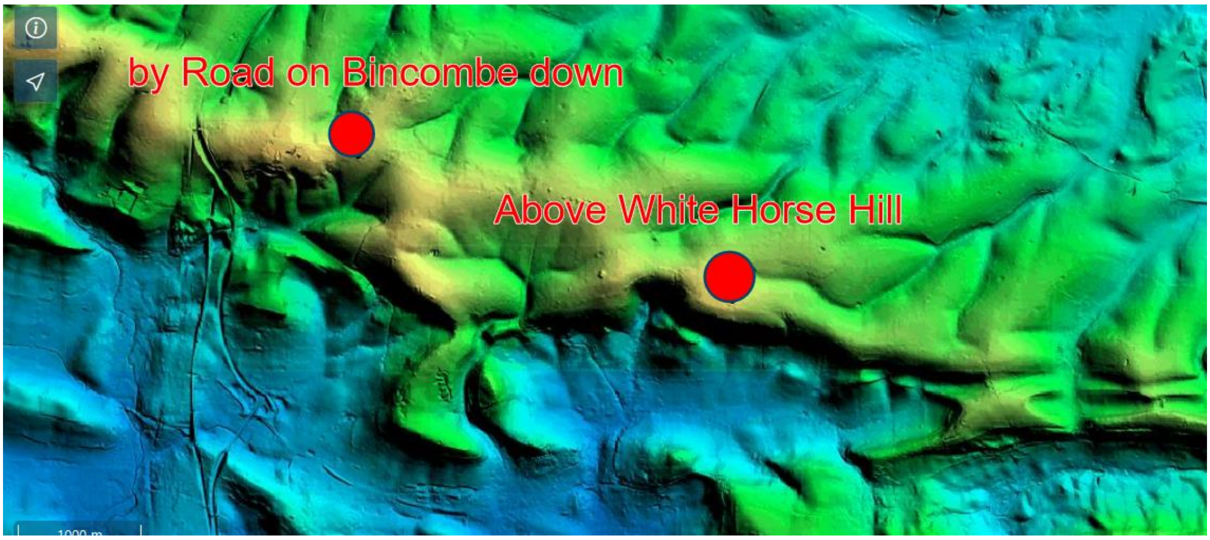

Figure 36 The positions of a east-west line of four round barrows close to the road on Bincombe Down and a similar group of three above the White Horse Hill . Both are on the southern edge of a ridge in a north-west , south-east direction. The former is G10 on Appendix 1, the latter G69. The image is depicted on a relief map where blue is lower

ground and green and orange higher). *The map comes from Dorset Explorer (Dorset Council 2024), and the DSM from that enjoys Crown copyright and database rights 2024 for Ordnance Survey AC0000830671 with additional copyright for Getmapping PLC and Bluesky 2024).*

6.C CONCLUSIONS

East-west lines of round barrows were only found in this area of Dorset, and nowhere else in the research area. This part of Dorset contains visually dominating east-west linear hills . The purpose of raising this was to point out the pattern of lines with a common orientation, which calls for explanation, which itself may be unrelated to celestial factors. It is possible that patterns of orientation may be influenced by physical context.

Chapter 7 CONCLUSIONS

The impetus for this study arose from an observation that the High Lea Farm round barrow cemetery in eastern Dorset appeared to be organised to ‘point towards’ the position on the South West horizon, close by Badbury Rings, where the Winter Solstice sun was seen to set. The review of the development of round barrows in Britain suggested that the earliest systematic organisation of round barrows in Britain was as lines, and that some were oriented towards solar extremes. The overall aim of this study was to assess whether there were any trends in the directions of lines of barrows in Dorset and the New Forest, and, more narrowly, whether there was a trend for lines to be oriented towards the Winter Solstice sunset. As far as the researcher knows, this is the first attempt to systematically study the orientations of lines of round barrows in Britain. The study developed seven criteria to identify lines of round barrows and carried out a systematic search of the research area to find such lines. The search used two methods to do so, a computer-based synthesis of lines of barrows from the locations of 3,587 known sites of round barrows and searching Historic England’s records of scheduled round barrows. The 71 lines of barrows identified were first examined individually using a case-study approach, which found two examples oriented towards the Winter Solstice, at Badbury Rings and Black Hill in Dorset. The whole set of lines was then analysed as a group together using an innovative programme, *skyscapeR* (Silva 2021) , which had been developed specifically for this type of study. The results did not find any significant overall pattern of direction in the 71 lines of barrows studied. An additional pattern of East-West oriented lines occurring in a specific area of Dorset was noticed by the researcher.

The first conclusion from this study was that there was no evidence of any significant recurring orientations of lines of round barrows in the study area. Previous identifications of lines with specific orientations (such as that which prompted this study) have been atypical, eye-catching, but rare. Systematically searching for and selecting lines of barrows finds the many that do not share orientations: they may have been organised in directions that reflect very specific rather than shared motives. The specific search for lines oriented towards the Winter Solstice was carried out in a different way, by calculating the declinations of all lines and identifying those with values of declination very close to that of the Solstice. Skyscape archaeologists might rightly criticise such a case-finding approach because the error involved in calculating individual estimates is unknown . One might also argue that a lack of a general trend increases interest in cases that stand against it. Of the only two such lines were found; one was in a site exceptionally rich in evidence of activity in all phases of the Bronze Age.

A second conclusion is a methodological one. Although Covid restrictions forced the decision to base the study on computer-based models of the horizon rather than on direct observation, this had advantages. One was that it constructed a potentially visible 360° bare horizon around each observation point . The views from a significant proportion of lines of round barrows are restricted by thick vegetation and nearby woodland, and also by barrows themselves, especially for lines are formed from a large central barrow and two small barrows, such as the Handley Hill group. (Figure 37).

Figure 37 The Handley Hill group of three barrows in a straight line, a large central barrow 2.7m high and 2 smaller one on either side of the central one, each about 1m high and invisible to each other. G36 in Appendix 1 (personal collection).

Producing a bare potentially visible horizon effectively makes such obstacles transparent. Some programmes, such as *skyscapeR*, are preferred to operate on complete 360-degree horizons, to achieve optimal results. It is sometimes difficult to provide this amount of data from direct observation.

Figure 38 The location of the line of barrows with the lowest elevation in the study. A set of three barrows , each less than 2m in height, covered in dead ferns, near Beaulieu Road Station, Denny Lodge, in the New Forest , G6 in Appendix1. (personal collection).

A third conclusion comes from the process of carrying out two methods of searching for lines of barrows. The two methods (searching the Historic England List online, and synthesising putative lines from a list of sites of round barrows) differed in the amount of time to complete searching and identifying lines . The former was more time-efficient, but the latter identified additional lines, mainly composed of the sites of ring ditches and sites that once stood but no longer exist. The current study used the more inclusive approach of utilising both methods in order to maximise the sample studied. The computer programme was commissioned to produce putative lines, but if that approach were to be used again the writer would require additional basic screening features to reduce work. The principle was sound, the system productive, but the output required many days of screening, and that burden might be overcome.

A fourth conclusion comes from the unexpected observation of a set of east-west oriented lines of barrows within a specific area of southern Dorset, and nowhere else. This orientation was not identified by the '*skyscapeR*' software, presumably because these lines are few in number, and three have one of the two measures of declination of each line (eastward or westward looking) exceeding 3°. The pattern was noticed when placing images of lines with different values of declinations onto a GIS map of the study area. It catches the eye because the potential occurrence of west-east orientations has been discussed critically by skyscape researchers (Ruggles 1997,Ruggles 2017, Belmonte, 2021). A major reason for scepticism is because the west-east orientation is almost identical to the astronomical concept of the equinox, a fleeting event, at which, dependent on the landscape context, on the same day the sun can be seen to rise and set in exactly opposite directions. Ruggles (2017) argues that east-west orientation has always seemed unlikely in structures built by prehistoric people, partly because doing so might require the ability to count days from another astronomical event in order to identify it with confidence. It is more likely that these east-west oriented lines of barrows in Dorset reflect the nature of the landscape than fleeting solar events, but the locations in which some monuments are built, possibly provide a specific solar or lunar experience, as implied by the word 'sky scape' which denotes this.

An observation that comes from visiting many lines of barrows concerns how they might have been used by the community that built them or lived with them. If, as it has been posited by scholars such as Bruck , and Johnston, they were a scene for local ritual or other events, how would they be used? Garwood's (2007) study looked for barrow groups that had been physically altered once since being first constructed. Some of these had been transformed to make a space in which potentially communal events could occur. Communities presumably used the same barrow groups in different ways over the many centuries of the long Bronze Age (and subsequently). Most lines studied here were simple and had no obvious display area. Another question about function arises about lines which looked in particular directions. How, if at all, would this feature have been used at communal or religious events? Would people stand alongside the barrows to look along them towards the important event (which may have been astronomical)? Would important people stand on top of the barrows, and have a clearer view, or see the first glimpse of sunrise or moonrise before others? Such thoughts about the ergonomics of lines of barrows can only be speculative, but they do raise the issue of the importance of how precise a line of barrows would have needed to be, as a line and also as a direction giver. Perhaps in many cases it might have been sufficient for most people to know that it pointed in a meaningful direction, without actually using the line to sight along? When the author was a young altar server he was informed that the altars in all the Church's churches contained a fragment of a saint's bones, and that this made it a sacred place. No-one knew who the saint was, but just knowing it was there made it a special place. An analogy might have been orienting a line in the direction of 'home', particularly relevant to a mobile population. A final relevant related obvious point is the variation in height of barrow. Some, such as the three barrows on Heathland near Beaulieu Road Station in the New Forest (Figure 31) were below a typical persons height : most , such as the Handley Hill Barrows near Sixpenny Handley (figure 40) were taller, and it would have been impossible to have an all-round view from beside the barrows. Such factors might influence how a line of barrows might have been used.

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LIST OF ABBREVIATIONS USED

aDNA Ancient DNA

BGS British Geological Survey

DSM Digital Surface Model

HER Historic Environment Record

LIDAR Light Indication and Ranging

NGR National Grid Reference

NHLE National Heritage List for England (Historic England)

NMP National Mapping Programme (Historic England)

RCHME Royal Commission on the Historical Monuments of England

TIFF Tag Image File Format (a format of images)

APPENDICES

APPENDIX A1

The 71 Lines of round barrows studied in this project

The information about each line includes, in order: *Code* (G no.): *Location*: *Total barrows in line* (implied by evidence); *Parish*: *County*: *how line was identified* in study (synthesised, from HE List, miscellaneous): *underlying Geology*: *NGRs* of westernmost (WB) and easternmost(EB) barrows: *elevation of line* in metres: references to line in *Historic England Listing* (HE#) and with suffixes prefixes *MDO (HER#)*; current state of line. Online addresses of HE, national HER , and Hampshire HER (for New Forest) are given at bottom of this table.

G1 Ashton Four**:** Winterborne St Martin; Dorset: synthesised, Listed: chalk: WB 365940,87200: EB 366138,87159: 146m: HE#1003217: HER MDO3200, HER MDO3203: part survives, one barrow in wood, visible to LIDAR.

G2 Badbury Rings, by B3082. Three: Shapwick Dorset: synthesised, Listed: chalk: WB 395834, 102947: EB 395898,102997: 83m: HE#1002716: extant.

G3 Badbury Rings, North of. Three: Pamphill: Dorset: miscellaneous: chalk: WB 396410,104310: EB 396420,104160: EB: 53m: HER MDO5875: none extant.

G4 Barnfield Heath. Four: St Leonards/St Ives: Dorset: synthesised: sand: WB 412099,100459: EB 412180,100510: 43m: HE#1017569 eastern barrow MDO5982. No access to check. Status unknown.

G5 Beaulieu Heath, 800m E of Dilton Farm Three: East Boldre: New Forest District: synthesised: clay, sand, and silt : WB 433960,100738; EB 434088,100800; 41m: HE1010069, HE1010377,HE1009967: extant three barrows.

G6 Beaulieu Road Station, SW of : Three: Denny Lodge : New Forest District: synthesised: sand; WB 434315,105883; EB 434317,105914; 25m; HE#1012565: extant three barrows.

G7 Bere Down Farm, SW of . Three: Bere Regis :Dorset: identified from Listing : chalk: WB 383380,96700: EB 383448 , 96543 : 65m : HE#1018193 : only, visible on LIDAR not extant.

G8 Bincombe Hill 'Bumps'. Six: Bincombe :Dorset: synthesised: chalk: WB 368895,84654: EB 369035,84581:157m: HE# 1002701 :extant.

G9 Bincombe Down, line across. Four: Bincombe: Dorset: synthesised: chalk: WB 369199,85262: EB 369324,85277:143m: HE# 1003305 (re two barrows); MDO24993 (re two barrows: to E): not extant.

G10 Bincombe Down, S of road. Four: Bincombe :Dorset: synthesised: chalk: WB 368425,85690: EB 368529,85690:147m: HE# 1002744 :traces visible on LIDAR, faint traces sometimes visible.

G11 Black Hill Three : Affpuddle and Turnerspuddle : Dorset: synthesised: Sand and Clay: WB 383630,94002: EB 383694,94057: 94m : HE # 1015897: all extant.

G12 Blackbush Plantation, SW area: Wimborne St Giles**.** Four : Dorset: Synthesised: chalk :WB 403127,115719 : EB403147,115877 : 89m: HE#1002795: extant.

G13 Bokerley Dyke, abutting. Three ; Martin; New Forest District: chalk: WB 404859,118936; EB 404865,118902: 93m: HE#1011006: three barrows extant.

G14 Bronkham Hill along NW slope. Six : Winterborne St Martin : Dorset: synthesised: chalk: WB 362609,86985: EB 362676,86862: 198 m: HER# 1002699: three barrows remain.

G15 Bronkham Hill along SE slope. Six : Winterborne St Martin; Dorset: synthesised: chalk: WB 362676,86869: EB 362817,86790 : 199 m: HE# 1002699: three barrows remain.

G16 Came Down Golf Course. Four : Winterborne Came: Dorset: Listed: chalk :WB: 368639,86175; EB 368662,86209: 150m: HE#1002712:Three barrows remain.

G17 Came Wood. Four Winterborne Came: Dorset; synthesised: chalk: WB 369675, 85456; EB 369824, 85429: 140m: HE# 1002742: Three barrows remain

G18 Chapel Hill Four. Four: Winterborne Came : Dorset: synthesised, Listed: chalk: WB 369774,87628: EB 369797,87730 : 97m: HER# MDO3070, MDO 3068: no remains.

G19 Charisworth Three. Three : Winterborne Whitechurch: Dorset: synthesised: chalk: WB 386080,101328: EB 386121,101349: 123m: HE#1002755 HER# MDO5349, MDO5336: no remains.

G20 Clyffe House, NW of. Three : Tolpuddle, Dorset: identified from Listing: sand: WB 377760,93013: EB377931,92855: 93m :HE#1016378: one barrow HER MDO2781:barrows visible on LIDAR.

G21 Corfe Common. Three : Corfe Castle: Dorset: synthesised:sand: WB 396513,80842: EB 396582,80817: 48m: HE#1011489: all extant.

G22 Creech Heath. Three : Church Knowle: Dorset: synthesised: clay: WB 392480,84020 :EB 392526, 84023:47m: HE#1014141: extant.

G23 Cripton Wood Four. Four : Winterborne Came : Dorset: synthesised: chalk: WB 369621,86587: EB 369807,86527 : 115 m: HE# 1003229 : three barrows in woods visible on LIDAR :extant.

G24 Culliford Tree. Seven: Whitcombe: Dorset: Synthesised : chalk: WB 369903,85474 : EB 370147,85368 : 140m: HE#1003304: five barrows extant.

G25 Damerham. Three: ,S E of Stapleton Farm : Rockbourne: New ForestDistrict: Synthesised: clay and silt: WB 408989,110509: EB 409144,11500: 51m :Hampshire HER # 65346,#65340: nothing visible.

G26 Dibden Purlieu Inclosure, S of: Four : Denny Lodge CP: New Forest District: synthesised: clay, sand, and silt: WB 440356,105054: EB 440373,105142: 40m; HE#1009003: extant four barrows.

G27 Ducks Egg, **North of**. Three : Rockbourne: New Forest: chalk; WB 410550, 120680; EB 410610,120760: 74m: Not extant.

G28 Eweleaze Barn. Five : Winterborne St Martin; Dorset: Synthesised, Listed: chalk: WB 364938,87209:EB 365010,87104:154m: HE#1002576: 4 remain.

G29 Fence N of King Down Farm. Four: Pamphill: Dorset: synthesised: Listed: chalk: WB 397270,104111: EB 396419, 104151: No remains: MDO5876, MDO5877, MDO5878, MDO5915. No remains.

G30 Five Marys. Six : Chaldon Herring: Dorset: synthesised, Listed : chalk: WB 378960,84208: EB 379097,84207: 99m: HE#1013344: extant all.

G31 Four Barrow Hill. Five: Winterborne St Martin; Dorset: synthesised, Listed: chalk: WB 365063,87873: EB 365176,88084: 148m: HE#1002755 HER#: four extant and visible on LIDAR.

G32 Fox Hill, on NW slope. Five: Denny Lodge : New Forest District: synthesised: sand : WB 436287,108307: EB 436462,108193: 28m: HE 1009750, HE 1009881, HE1009879, HE1009751, HE 1009873; extant 5 barrows.

G33 Goldcombe Farm, west of. Four: Winterbourne Steepleton: Dorset: synthesised: chalk; WB 361883,87881; EB 362141,87973: 185m; HE#1003307; HER# MDO3376; unknown, unclear.

G34 Golden Cap. Four : Stanton St Gabriel: Dorset: identified from listing: chert: WB 340540,92085: EB 340572,92128: 187m: Account of recent excavation PDNHAS V134 2013 p205-247:#. HE#1016373 ; extant 3 barrows.

G35 Great Hill, east of. Five: Winterborne St Martin: Dorset: synthesised: chalk: WB 363807,86859: EB 364056,86768: 154m: HE#1004564;HER# MDO3516: at least three extant, visible on LIDAR. Partial survival.

G36 Grove Hill Four. Winterborne St Martin: Dorset: Miscellaneous: chalk: WB 363868,88487 EB 364117,88514:135m: HE#1002757: HER# MDO3177: survival unknown.

G37 Handley Hill Group. Three : Sixpenny Handley: Dorset: synthesised, Listed: chalk: WB 401352, 116234: EB 401413,116277: 113m: HE# 1002791: all extant.

G38 Hardown Hill. Three : Whitchurch Canonicorum: Dorset: identified from listing : chert: WB 340555,94468 : EB 340565,94520 : 201m: HE#1016375: extant.

G39 Higher Came Farm, E of . Five: Winterborne Came : Dorset: synthesised: chalk: WB 369844,87065: EB 369907,87242 : 115 m: HER# W MDO 25109, MDO25107 : No remains.

G40 Higher Came Farm, N of. Five: Winterborne Came : Dorset: synthesised: chalk: WB 369383,87494 : EB 369611,87509 : 98 m: HE# 1002828 :HER MDO3053, MDO 3075 MDO 3076 : no remains.

G41 Holme Mount. Three : East Holme: Dorset. Synthesised, Listed: sand: WB 390687,84421: EB 390701,84297: 62m: HE 1008143 re 2 barrows: HER re one barrow MDO7638: two visible.

G42 Knowle Wood Farm, **NW of .** Four : Woodlands: Dorset: synthesised: chalk: WB 403093,110184 ; EB 403219,110072; 185m ; MDO40148, MDO40140 ; no remains.

G43 Long Bottom . Three : Frampton: Dorset: synthesised: chalk: WB 361004, 93248; EB 361058,93206; 122m; HER# MDO21263 and also MDO21265;.None extant.

G44 Longland Group. Three : Winterborne Abbas: Dorset: synthesised, Listed: chalk: WB 359976,89760; EB 360030,89791 ;154m; HE#1013265; HER#MDO3316: none extant.

G45 Lulworth Heath. Five : Steeple-Tyneham: Dorset: synthesised, Listed: sand: WB 387577,84092: EB 387613,83925: 27m: HE#1007694. NW: most are extant.

G46 Middlebere Heath. Three : Arne: Dorset: synthesised, Listed: sand: WB 393889,84411: EB 393936,84409: 35m; HE #1011481: all extant.

G47 Money Hill .Three : Copythorne: New Forest District: synthesised: Clay, sand, and gravel: WB 431728,114926; EB 431811,115087; 36m: HE#1003465: three visible remains.

G48 Moonhills Carpark, **North of**. Four : Denny Lodge CP: New Forest District: synthesised: clay, sand, and silt; WB 440968,102638; EB 441049,102574: 33m; HE#101753 and also 1013115: extant 4 barrows.

G49 Pentridge. Four: Pentridge: Dorset: synthesised: chalk: WB 403451,118042: EB 403640,118162: 102m: HER MDO 5951:none visible, from AP.

G50 Pitts Copse Farm Heath. Three : Fawley: New Forest District; synthesised; clay, sand, and silt; WB 442062,103810, EB 442064,103848; 37m: HE#1013206: extant three barrows.

G51 Povington Heath. Four Barrows, NE Four : Steeple-Tyneham: Dorset: synthesised: : clay, silt : WB 387679,81800: EB 387700,81820 : 60m HE# 1008026: HERs MDO8069, MDO8068, MDO8067: extant in that visible on LIDAR.

G52 Povington Heath Three Barrows. Three : Steeple-Tyneham: Dorset: Synthesised, Listed: sand: WB 388551,83718: EB 388570,83756: 26m: HE# 1007693: extant 3 barrows.

G53Poxwell Big Wood, S of. Three : Osmington: Dorset: synthesised, Listed: chalk: WB 374924, 82605: EB 375200,82570:123m: two barrows referred to in HE 1003584, one HER MDO 1832: 3 extant.

G54 Puddletown Down. Three : Puddletown: Dorset: listed: chalk: WB 375201 97496; EB 375339,97422: HE 1002450: partially extant, visible on LIDAR.

G55 Ridge Hill. Three: Weymouth: Dorset: Synthesised, Listed: chalk: WB 365558 86589 : EB 365740,86620: 162m: HE# 1002760: WB MDO6614: extant eastern 2 barrows .

G56 Rockbourne Down .Three: Rockbourne : New Forest District: Synthesised: chalk: WB 410562,121078; EB 410580,121120: 73m. New Forest HER refs. 21718,21685: survival unknown.

G57 Seven Barrows Farm, N of . Three : Wareham Town: Dorset: synthesised, Listed: sand: WB 391211,88784 EB 391253,88822: 34m: HE#1015373: all extant.

G58 Seven Barrows Farm , S of. Three : Wareham Town: Dorset: Synthesised, Listed: sand: WB 391148, 88655: EB 391179 88712:34m: HE#1015374: all extant.

G59 Shorn Hill . Four : Winterborne St Martin: Dorset: Synthesised, Listed: sand: WB 362979,87290: EB 362988 87215: 167m: HE# 1002674. HER: HE#1002699. MDO 6365: three extant good condition.

G60 Stinsford. Six: Stinsford: Dorset synthesised: chalk: WB 371005, 92134 : EB 371147,92022: 84m: HER MDO20435, MDO20436,MDO20437, MDO20438, MDO20524 MDO20525: no remains.

G61 Stony Cross Plain. Four ; Minstead: New Forest; sand, silt, and clay: WB 425750,111450; EB 425810,111390; 113m; Hampshire HER online: extant? None clear.

G62 The Butts. Six : Godshill; New Forest District; synthesised; sand, silt, and clay: WB 421389,115656; EB 421449, 115691; 114m; HE#1012538: extant six damaged barrows survive.

G63 Thomas Hardye School. Four: Dorchester: Dorset: synthesised: chalk: WB 367756,89966: EB 367851,89971: HER MDO18770. Barrows totally excavated, as reported in PDNHAS vol 128 2007,17-52.

G64 Veiny Cheese Pond. Five: Crichel: Dorset; synthesised: chalk: WB 396671,111747:EB 396734,111659: HER MDO5826: not extant.

G65 Wellbottom Wood, 500m W of. Three: Little Bredy: Dorset: synthesised: chalk: WB 358712,90144 : EB 358751,90111: 178m: HE#1013252: none visible.

G66 Wellbottom Wood, 300m SW of. Three: Little Bredy: Dorset: synthesised, Listed: chalk: WB 358822 89941:EB 358865,89867 : 181m: HE 1013251: remains of three visible.

G67 West Hill. Seven: Bincombe: Dorset: synthesised, Listed: chalk: WB 370186, 84611: EB 370483,84734: 135m: HE#1002771: visible on LIDAR, not clear on ground.

G68 Whitcombe Barn, 330m S of. Four: Whitcombe: Dorset: Synthesised, Listed: chalk: WB 370677,86275 : EB 370795,86169 : 190 m: HE#1019414: WB MDO2959, MDO2961: no extant.

G69 White Horse Hill, NW of, on ridge. Three : Osmington: Dorset: synthesised: chalk: WB 371440,84530: EB 371460,84530: 151m: HER MDO1824: not visible.

G70 Wimborne St Giles, by B3081 in trees. Four: Wimborne St Giles by B3081: Dorset: Synthesised : chalk: W B404078,112306 : EB 404155,112272 : 68m: HE#: 1002780. Extant.

G71 Worbarrow, NE of. Three: Wimborne St Giles: Dorset: Synthesised: chalk: WB 401798,117529: EB 401850,117551: 93m: HE# 1002674 HER# ; MDO 6365: one mound remaining.

Further Information

A. For HER# numbers (Heritage Gateway) go the following address and insert index

number e.g. MDO6365 https://www.heritagegateway.org.uk

B. For HE# numbers go to the following address and insert number in list Search the

List https://historicengland.org.uk/listing/the-list/

C. Hampshire HER (covers new Forest).

https://maps.hants.gov.uk/historicenvironment/

Appendix A2
Table 6: Key facts about each line of barrows.

Line Index	Title of Line	Azimuth West-East In degrees	Azimuth East-West In degrees	Distance of line in metres	Total of Barrows in line
G1	Ashton	101.3	281.3	234	4
G2	Badbury Rings	50.61	230.61	98	3
G3	Badbury Rings North of	176.1	356.5	172	3
G4	Barnfield Heath	57.94	237.94	114	4
G5	Bealieu Heath	64.53	244.53	166	3
G6	Beaulieu Rd Station	4.07	184.07	45	3
G7	Bere Down Farm	156.4	336.4	184	3
G8	Bincombe Hill (Bumps)	117.9	297.9	186	6
G9	Bincombe Down, Line Across	82.82	262.82	137	4
G10	Bincombe Down, S of Road	89.6	269.6	126	4
G11	Black Hill Three Barrows	49.14	229.12	105	3
G12	Blackbush Plantation SW area	7.25	187.25	184	4
G13	Bokerley Dyke, abutting	170.04	350.05	48	3
G14	Bronkham Hill along NW slope	151.01	331.01	146	6
G15	Bronkham Hill along SE slope	118.85	298.85	193	6
G16	Came Down Golf Course	33.74	213.73	72	4
G17	Came Wood	99.94	279.94	195	4
G18	Chapel Hill	12.38	192.38	134	4
G19	Charisworth Three	62.72	242.72	52	3
G20	Clyffe House, NW of	132.49	312.49	268	3
G21	Corfe Common	109.88	289.88	98	3
G22	Creech Heath	86.19	266.19	61	3
G23	Cripton Wood Four	107.54	287.54	222	4
G24	Culliford Tree	113.15	293.15	301	7
G25	Damerham	129.05	309.06	198	3
G26	Dibden Purlieu S of	11.58	191.58	126	4
G27	Ducks Egg N	36.99	216.99	167	3
G28	Eweleaze Barn	145.18	325.18	176	5
G29	Lulworth Heath Five	169.14	349.14	216	5
G30	Five Marys	90.19	270.19	168	6

continues overleaf….

Continuation of Table 6 (Appendix A2)

Line Index	Title of Line	Azimuth West-East	Azimuth East-West	Distance of line in metres	Total of Barrows in line
G31	Four Barrow Hill	27.79	207.79	279	5
G32	Fox Hill	123.48	303.48	233	5
G33	Goldcombe Farm	69.57	249.57	300	4
G34	Golden Cap	36	216	62	4
G35	Great Hill	109.68	289.68	309	5
G36	Grove Hill	83.41	263.41	288	4
G37	Handley Hill	54.83	234.83	97	3
G38	Hardown Hill	10.23	190.23	64	3
G39	Higher Came Farm E	19.26	199.26	216	5
G40	Higher Came Farm N	85.9	265.9	285	5
G41	Holme Mount	173.46	353.46	149	3
G42	Knowle Wood Farm North of	131.67	311.67	191	4
G43	Long Bottom	127.45	307.45	81	3
G44	Longland Group	59.7	239.7	86	3
G46	Middlebere Heath	92.4	272.4	76	3
G47	Money Hill	27.63	207.63	213	3
G48	Moon Hills	128.76	308.76	118	4
G49	Pentridge	57.63	237.63	231	4
G50	Pitts Copse Farm Heath	3.25	183.25	62	3
G51	Povington Heath Four Barrows	46.26	226.26	32	3
G52	Povington Heath Three Barrows	42.14	222.14	35	3
G53	Poxwell Big Wood, South of	96.95	276.95	289	3
G54	Puddletown Down Three Barrows	117.93	297.93	177	3
G55	Ridge Hill	79.96	259.96	238	3
G56	Rockbourne	23.31	203.32	59	3
G57	Seven Barrows Farm, N of	47.77	227.77	119	3
G58	Seven Barrows Farm,S of	28.44	208.44	82	3
G59	Shorn Hill	172.75	352.75	104	3
G60	Stinsford	127.94	307.94	227	6
G61	Stony Cross Plain	135.38	315.38	105	4
G62	The Butts	59.8	239.8	89	6
G63	Thomas Hardye School	86.63	266.63	116	4
G64	Veiny Cheese Pond	144.36	324.36	118	5
G65	Wellbottom Wood 500m S	129.78	309.78	77	5
G66	Wellbottom Wood 300m S	149.39	329.39	121	3
G67	West Hill	67.18	247.18	412	7
	Continues overleaf…				

Continuation of Table 6 (APPENDIX A2)

Line Index	Title of Line	Azimuth West-East	Azimuth East-West	Distance of line in metres	Total of Barrows in line
G68	Whitcombe Barn	131.62	311.62	190	4
G69	White Horse Hill, above	89.69	269.69	39	3
G70	Wimborne St Giles by B3081	113.87	293.87	108	4
G71	Worbarrow	67.09	247.09	75	3

Notes

Titles of Line and Codes of Line are those of Appendix 1

Azimuth ‘WE' is the value of azimuth looking from western barrow towards eastern barrow

Azimuth ‘EW' is the value of azimuth looking from eastern barrow towards western barrow

Polar Plots of these data form Appendix 2.

Distance of the Line in metres' is the distance from the west edge of the western barrow to the eastern edge of the eastern barrow.

Appendix A3

Polar Diagrams representing the Azimuths of lines in Study 2

The azimuths of the 71 lines of barrows are displayed below in three polar diagrams. In Figure 39 each line represents the azimuth towards the easternmost barrow of a line, as seen from the westernmost barrow in that line. Figure 40 represents the reverse, the azimuth towards the westernmost barrow of a line, as seen from the easternmost barrow in that line. Figure 41 is a combination of Figures 39 and 40.

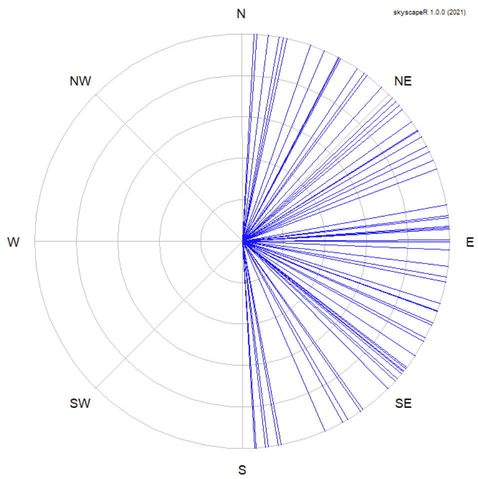

Figure 39 A polar plot of azimuths of each of the 71 lines as measured from westernmost barrow of each line, towards the easternmost barrow of that line (personal collection 2024).

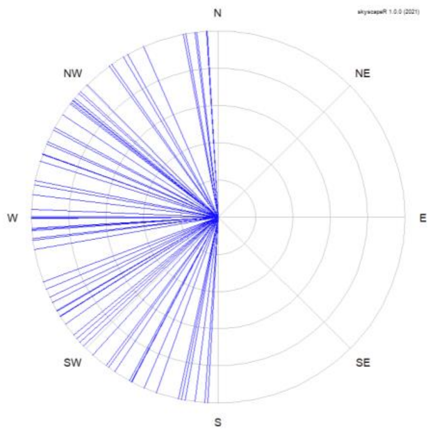

Figure 40 A polar plot of azimuths of each of the 71 lines as measured from easternmost barrow of each line, towards the easternmost barrow of that line (personal collection 2024).

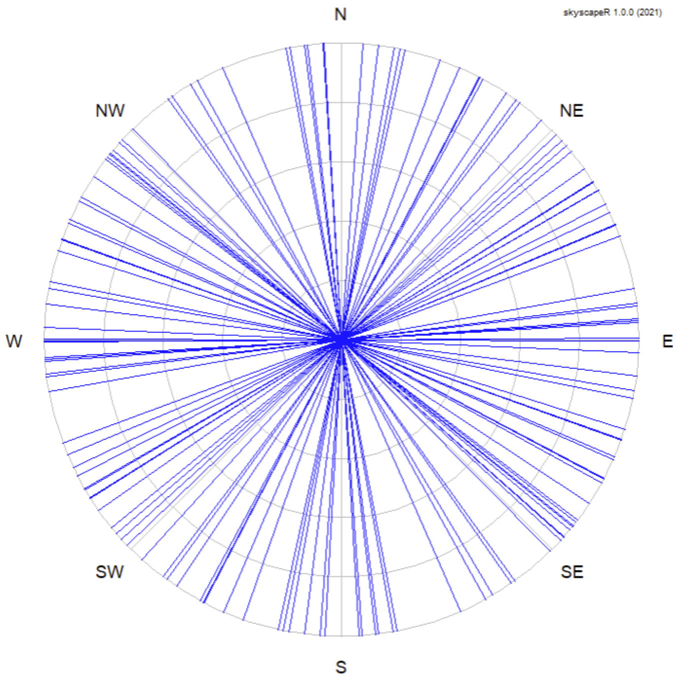

Figure 41 (identical with Figure 26) A polar plot of azimuths of each of the 71 lines as measured from both the easternmost barrow of each line, towards the easternmost barrow of that line and vice versa (i.e. a combination of Figures 38 and 39, which are mirror images of each other) (personal collection 2024).

There are a few areas empty of lines, and several areas with a thin bundle of lines (eg WNW to ESE - c.300° to 120°, and NNE to SSW- c. 50° to c 230°). If one is interested in directions towards events on the horizon, these azimuths are of limited value, as they cannot take into account the altitude of horizons at these points. Converting them into measures of declination can do this. This is explained more clearly in Appendix 47.

Appendix A4

The reason for rejecting some lines of barrows from the study is because of close neighbouring barrows.

Some otherwise acceptable lines of barrows are transformed into something else, such as triangles, if another barrow is placed next to them. Below are examples .

Example 1

One is a short line of three barrows, part of a Scheduled large group of barrows in 'The Drive Plantation' on the Shaftesbury Estate in Gussage All Saints (HE**. List ID:** 1002788 (NGR 401243 115230). The line of three is visible on LIDAR (below). Opposite to the central barrow is a neighbouring fourth barrow, which changes the constellation. This fourth barrow was visible on the OS 6" to the mile map of 1888-1913 and is opposite the central barrow which changes this from a very short linear group into something else and this is why the line is rejected.

Figure 42 The third neighbouring barrow makes the line of three unacceptable for the study. The map above contains Ordnance Survey OpenData © Crown copyright and database rights[2023].

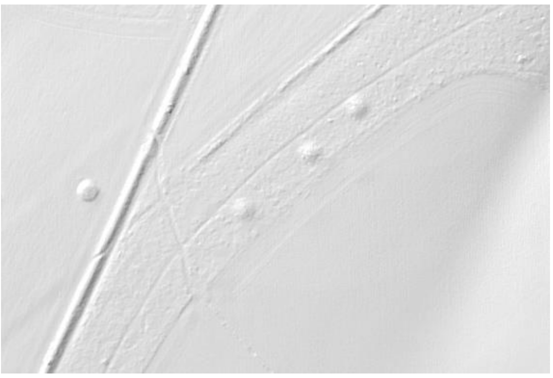

Figure Appendix 43. A LIDAR image of Figure 42 lidar image is copyright © The Environment Agency and/or database right 2022. All rights reserved .

Example 2

A second example is from a set of three round barrows on King Down, Pamphill (NGR 398056, 103462) where the three Scheduled barrows are faced with a neighbour so close as to make the trio not acceptable for the study. All barrows were visible on the OS 6" to the mile map of 1888-1913 .

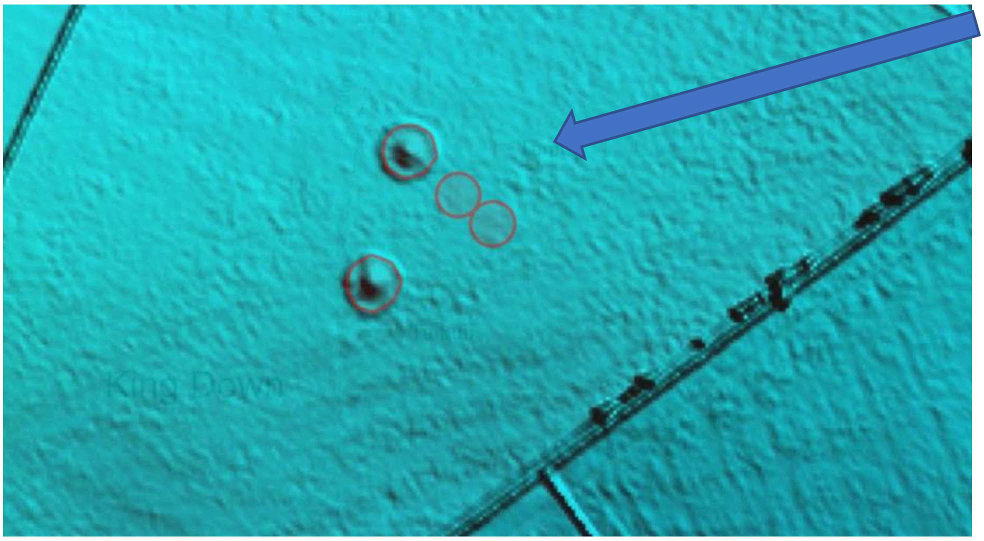

Figure 44 A digital surface model (DSM) of extant barrows at King Down

Crown Copyright and database rights 2024OS A C0000830671, (c)Get Mapping PLC and Bluesky International 2024: © Dorset Council 2024

Figure 45 Ordnance Survey Map of King Down. Copyright Ordnance Survey Crown Copyright and database rights 2024 OS A C0000830671: (c) Dorset Council 2024 .

Appendix A5

The Logic of the line-finding programme used to identify possible lines of round barrows from a list of the locations of round barrows.

The line- finding programme was produced to synthesise possible lines of round barrows from a list of National Grid References (NGRs), being the locations of round barrows, kindly provided by the Historic Environment Records of Dorset and of Hampshire. This Appendix starts by explaining the logic of screening sets of barrows in order to find lines involved, by taking each barrow location in turn as the index barrow. The programme would compute distances between that index barrow and all other 3,586 barrows in the set .

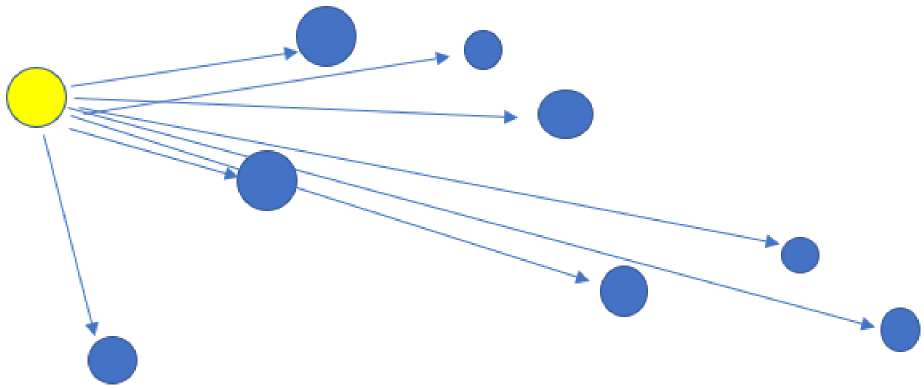

Figure 46 Look at relationships between the 'Index barrow' (yellow) and all others known (personal collection 2024).

The programme would then select the barrow closest to the index barrow and draw a notional line passing through and extending beyond the centres of this nearest neighbour and the index barrow (Figure 46).

Decide on a distance, say, *d* meters and construct imaginary straight lines parallel to the notional line running through and beyond the centres of the index barrow and nearest neighbour, and d meters apart from that line (2d from each other). This defines a track 2d metres wide running along a direction continuing that between the two barrows (Figure 47.

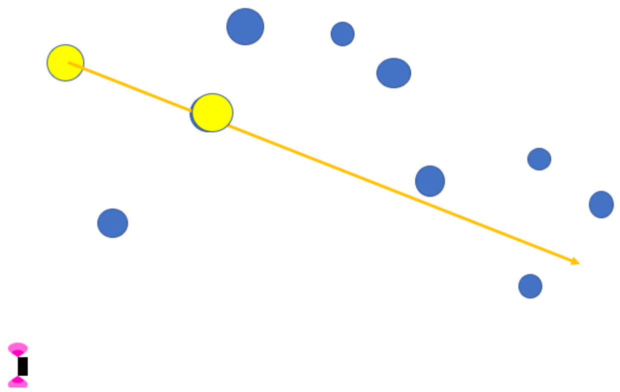

Figure 47 Select the barrow nearest the index barrow and draw a line between the index and its nearest neighbour and extend the line (personal collection 2024).

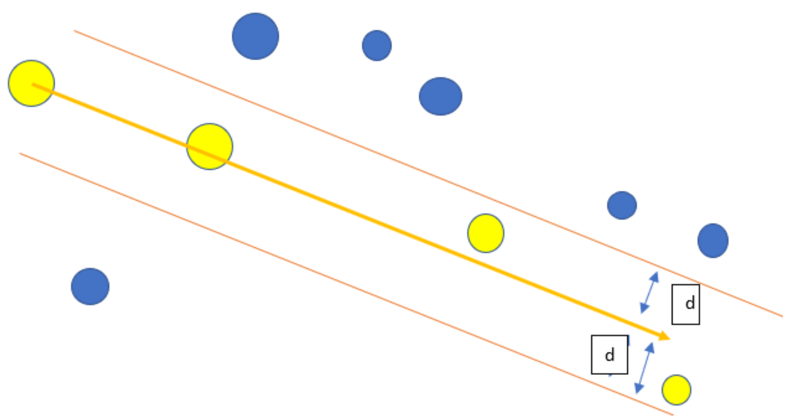

Figure 48 Select further members of the line of barrows by selecting an area so that barrows that inhabited the space were seen as members. The area was selected as that within distance d from the line (i.e., a track in the same direction as the line), (personal collection 2024).

The programme then looks for other barrows which have centres within the defined track at distances progressively further away from the index barrow in each direction. If the centre of a barrow lies within the track it is included within the set of barrows defined by the index barrow and its nearest neighbour. Sets containing at least 3 barrows will be available for further examinations, to assess whether they meet the criteria for entry into the study. A maximum distance from the index barrow would be set so as to exclude obvious outliers, the value of d can be varied, and the programme can be set to minimise inevitable duplication in the sets produced.

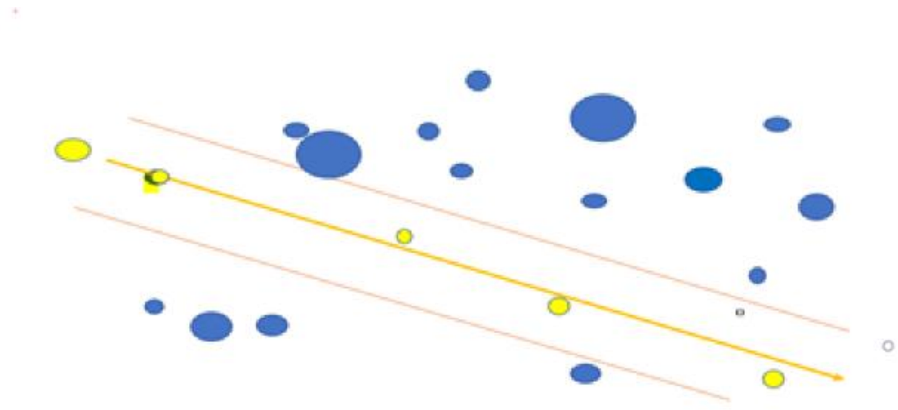

Figure 49 Keep choosing barrows within the defined space until you reach a maximum distance from the Index barrow. The next barrow on a list becomes the next index barrow and the process continues until every barrow has played the role of an index barrow (personal collection 2024).

Once one potential line is exhausted, with or without discovering a line of barrows, the programme takes another barrow and repeats the logic on that, and eventually on all 3587 barrows. The logic is to find potential lines within groups of barrows, in a simple way, not taking account the sizes of barrows or slope, or other important features of the landscape.

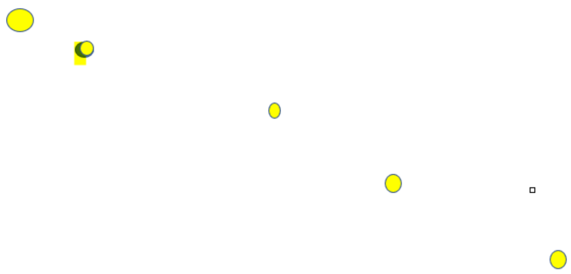

Figure 50 As the process moves on it may leave lines composed of barrows. These are the possible lines to be studied further for suitability (personal collection 2024).

This is the logic of the computer programme. The writer designed it and had a programmer write it in the *Python* language. Some of the basic code is written in Appendix 4

Appendix 6

The use of the programme in synthesising lines and examining these.

The output from the line-finding programme was sequences of code for NGRs representing from three to more than 20 barrow locations. Some were meaningless, as was expected when using it with a degree of latitude to allow for false positives. Several lengths of shorter code are reproduced below from page 6 of a run where the maximum length of groups of barrows was set at 800m, the maximum separation between barrows was 450m, and the maximum distance from the line between the centre of a barrow and the line passing through the centres of the first two barrows was 8m. Each group consists of a barrow number (e.g., '600') and the OS easting and northing of its centre. Therefore, in the following list of four consecutive sequences of code (each enclosed within square brackets) are lists each containing a reference number, and, to its right, within curved brackets, an NGR of an easting and then northing. Thus, the first line depicts three barrows, the second four barrows and so on. There is repetition of individual barrows.

[600(365059,87869), 605(365101,87924), 608(365130,87972, 6.1)]

[610(365148,88033), 615(365174,88086), 605(365101,87924, 5.8), 600(365059,87869, 7.7)]

[621(365298,86588), 622(365330,86583), 625(365361,86578, 0.2), 627(365404,86566, 5.4)]

[636(365558,86589), 641(365666,86609), 627(365404,86566, 5.4), 645(365740,86620, 2.7)]

Figure 51 Some lines of data output from the line-drawing programme

The writer fed the NGRs into a website system (Dorset Explorer, 2023) which can be made to display NGRs on a large-scale OS map, along with the positions of Scheduled monuments, basic LIDAR, historic OS maps etc. Four of NGRs composed part of a line of the five Scheduled round barrows forming the 'Four Barrows' Group (Figure A2.7). These are clearly visible on the option for '2m digital surface model' and on that for the 'OS '6" map of 1888 to 1913'. The NGRs in the first two lines refer to a list of Scheduled round barrows forming what is known as the 'Four Barrows' Group' in Winterborne St Martin, Dorset. The barrows were marked on the 1889-1913, 6" OS map and are clearly visible for the option for '2m digital surface model' . This points to some of the features of this basic programme: it sometimes, but not always, lists members of identifiable groups. It sometimes marks sites of barrows that aren't there, possibly an error in the data used. The third and fourth lines of data on Figure A2.7 refer to lines of barrows on Ridge Hill, close to the South Dorset Ridgeway. The programme is an imperfect but helpful heuristic aid for identifying potential lines of round barrows from a list of locations.

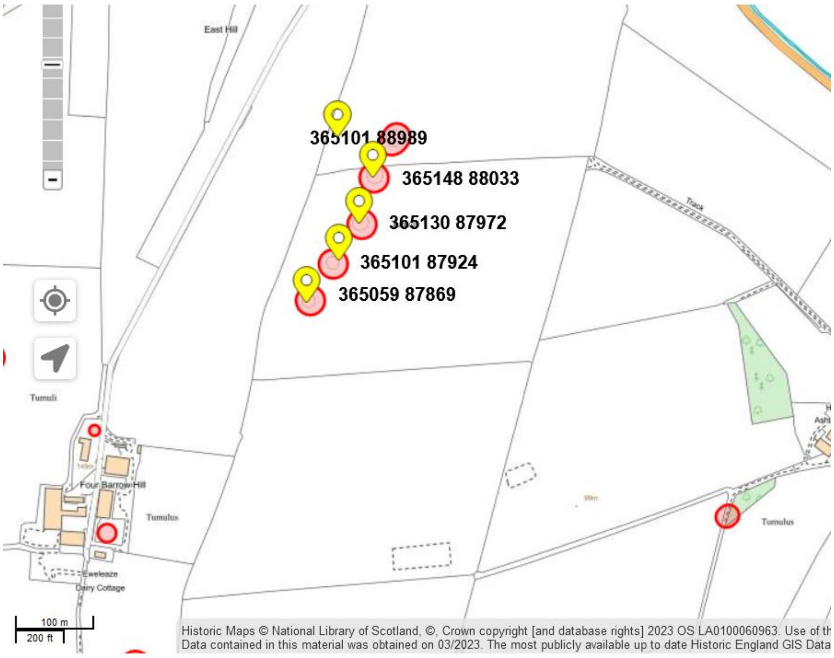

Figure 52 Examining output from the line-finding programme on an Ordnance Survey map. The barrows identified are marked in yellow on an Ordnance Survey map, that is the copyright of Historic Maps @ the National Library of Scotland. Crown Copyright (and database rights) OS LA0100060963

Figure 53 A copy of the relevant part 6 Inch to the mile OS historic mapping from the National Library of Scotland NLS OS 6 Inch to the Mile (1888-1913) Crown Copyright

A.7 The code for the line-synthesising finding programme

The computer programme produces lists of locations, as in the above example. Below is a listing of the programme written in Python. The programme reads a list of NGRs in CSV (comma separated values) format. It is possible to set parameters of the search, including the maximum distances between barrows, and the width of the 'track' . Below is the code used.

```
import csv

import numpy as np

from scipy.spatial import distance_matrix

SIEVE = 500

INTER = 100 # INTER is always < SIEVE

CLOSE = 5

path_to_csv_file = "test_data_254.csv"

# the following gets input data from a rb254 in a data.py file

#from data import rb254

# get data from csv file



rb254 = []

with open(path_to_csv_file) as csv_file:

    csv_reader = csv.reader(csv_file, delimiter=",")

    line_count = 0

    for row in csv_reader:

        rb254.append([int(row[0]), int(row[1]), int(row[2])])
```

```
def distance_point2line(p1, p2, p3):
    _p1 = np.array(p1)
    _p2 = np.array(p2)
    _p3 = np.array(p3)
    return np.abs(np.cross(_p2 - _p1, _p1 - _p3))/np.linalg.norm(_p2 - _p1)


rb254 = sorted(rb254, key=lambda x: x[2])
# get coordinates alone
coords = [y[:2] for y in rb254]
IDs = {}
ids = []
for i in range(len(coords)):
    IDs[rb254[i][2]] = i
    ids.append(rb254[i][2])
dist = distance_matrix(coords, coords)
#
potential_l = []
indexes = None
for i in range(len(ids)):
```

```
    tmp = []
    for t in sorted(list(set(dist[i]))):
        if t < SIEVE:
            indexes = np.where(dist[i] == t)
            if(indexes[0].size):
                for index in indexes[0]:
                    tmp.append(ids[index])
        else:
            if(len(tmp) > 2):
                potential_l.append(tmp)
            break


#for index_borrow in potential_lines.keys():
group_step_e = []


for l in potential_l:
    s = 1
    for i in range(len(l) - 1):
        if dist[IDs[l[i]], IDs[l[i+1]]] < INTER:
            continue
        else:
```

```
                s = 0

                break

            if i < 2: # fewer than 3 barrows remain in the group

                continue

            else:

                group_step_e.append(l[:i+1+s])



        # Step F

        group_step_f = []

        for g in group_step_e:

            tmp = g[:2]

            for i in range(2,len(g)):

                proj_d =
distance_point2line(coords[IDs[g[0]]],coords[IDs[g[1]]],coords[IDs[g[i]]])

                if(proj_d < CLOSE):

                    tmp.append(g[i])

            group_step_f.append(tmp)

        # Step G: part e for previously filtered barrows

        group_step_g = []

        for i in range(len(group_step_e)):

            _diff = [group_step_e[i][0]] + list(set(group_step_e[i]) - set(group_step_f[i]))
```

```
    if(len(_diff) >= 3):
        s = 1
        for i in range(len(_diff) - 1):
            if dist[IDs[_diff[i]], IDs[_diff[i+1]]] < INTER:
                continue
            else:
                s = 0
                break
        if i < 2: # fewer than 3 barrows remain in the group
            continue
        else:
            group_step_g.append(_diff[:i+1+s])
# Apply F computation to the results of Step H



group_step_gh = []
for g in group_step_g:
    tmp = g[:2]
    for i in range(2,len(g)):
        proj_d =
distance_point2line(coords[IDs[g[0]]],coords[IDs[g[1]]],coords[IDs[g[i]]])
```

```
        if(proj_d < CLOSE):
            tmp.append(g[i])
    group_step_gh.append(tmp)



# Final group

final_group = []
for line in group_step_f:
    if(len(line)>=3):
        final_group.append(line)

# Add to final group altenative lines that are 3 long or more

for alt_line in group_step_gh:
    if(len(alt_line)>=3):
        final_group.append(alt_line)

# Filter out lines which are included in other lines

full_list = []
```

```
def check_if_subset(full_list, l):
    for line in full_list:
        if(set(l).issubset(set(line))):
            return True
    return False


for _line in sorted(final_group, key=lambda x: -len(x)):
    if not(check_if_subset(full_list, _line)):
        full_list.append(_line)


for l in full_list:
    print(l)
```

Appendix A8 The notion of 'Declination' and how to measure it

One of the problems with communicating about astronomical events is that one is talking about one's own view, seen from one's own viewpoint. Science is about more than the viewpoints of individuals, and a solution to this, the notion of 'declination', is a better way of measuring the positions of celestial events.

A8.A The importance of the notion of declination

The azimuth (number of degrees clockwise from due north) of a relevant feature of a structure as seen from a specific spot, is of great interest, but is related to the specific locations of the structure and observer. Research into the orientation of a set of structures needs to use an index of that relationship that is independent of where it is viewed from.

As an example, consider three sites in the Isle of Purbeck in South East Dorset, which consists of three types of landscape, an area of undulating heathland in the North, a long curvilinear East-West hill chalk hill abutting the heath from the south, and a mixed geological area to the south between the hill and the sea cliffs (Figure 53).

In 2002 the azimuth of the Winter Solstice Sunset seen on the horizon from Rempstone stone circle, 200m to the north of the linear Purbeck hill, was 200.2°; that from the eastern mound of Creech Heath Barrows, 1.8km to the north of the hill, was 227.3°; and that from Swyre Head barrow, a large barrow on a headland above the sea, c 1km to the south of the hill , was 232°. Images of the position of that sunset as observed from each structure are given in Figures 54, 55, and 56.

Although these monuments are just a few km apart there is a 32° variation in the azimuth of the same celestial event as seen from them, largely because of the presence of the curvilinear hill between the Rempstone Circle and Swyre Head. The azimuth of an event as seen from a location is not suitable for comparing directions of groups. The location is taken into account in computing values of declination by of monuments, which is the core of the current research question . The index of astronomical declination is a better index than azimuth for this task, because it is independent of the location of the observer including the latitude of the observer's location in the calculation Seen from any spot, there is a one-to-one correspondence between values of declination and points on the horizon. Declination is the ideal index to use to measure the orientations of lines of round barrows towards the horizon, by surveying the area on the horizon towards which they 'point'.

Figure 54 The positions of three Bronze Age monuments in the Isle of Purbeck South East Dorset Copy of a feature of Ordnance Survey map, copyright of Ordnance Survey. (c) Crown copyright and database rights 2024 OS AC0000830671.

Another feature of astronomical events is that, due to predictable long-term changes in the relationship between sun and earth, the values of declination of specific events such as the Winter Solstice sunset fluctuate predictably over time (Ruggles 1999, p 57). The value of the declination of the winter solstice sunset in the probable year of the death of the person interred in the second largest barrow at High Lea Farm, described in the Preface, was close to -23.9° . That corresponding to that site in 2022 was close to -23.5°, the difference in declination between the two dates would be approximately that of one diameter of the sun. The index,' declination', can be used to clarify which structures are orientated in the same way and thereby link landscape archaeology with celestial events on the horizon.

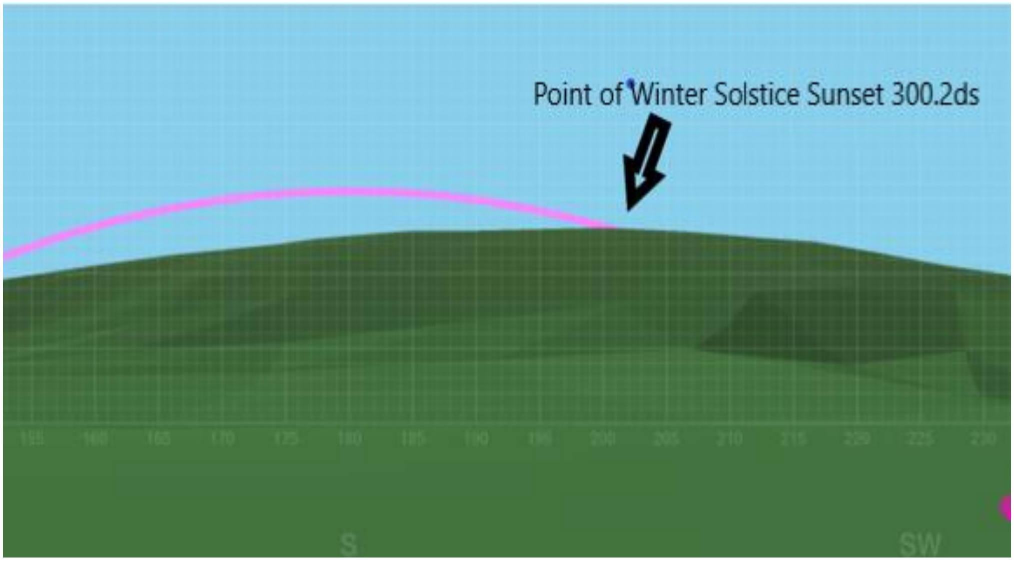

Figure 55 The position of the Winter Solstice Sunset in 2022, as seen from Rempstone Stone Circle, is at an azimuth of 200.2°. Image produced from ‘Horizon‘ Programme (copyright Smith 2020) using Terrain 50 data from Ordnance Survey under the Open Government Licence.

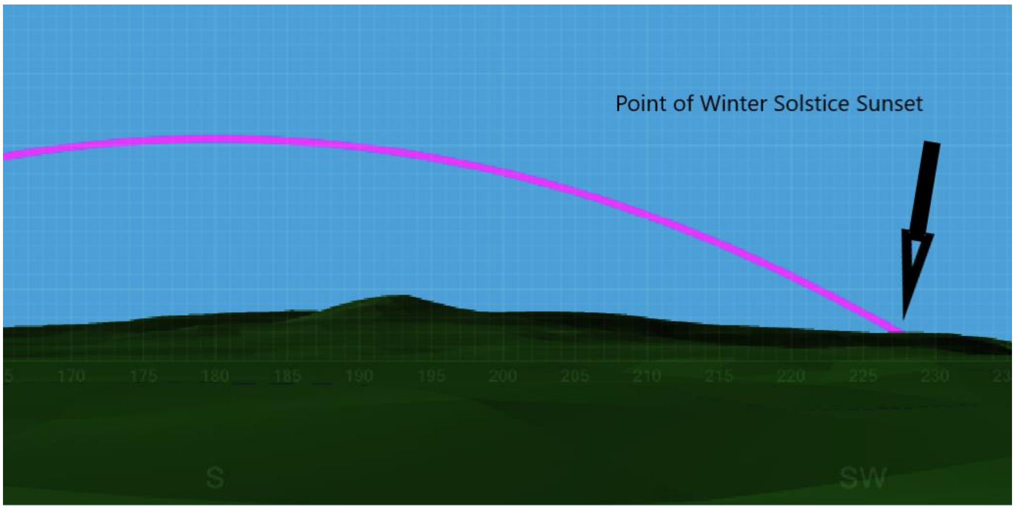

Figure 56 The position of the Winter Solstice Sunset in 2022, as seen from the eastern mound of the line of three barrows on Creech Heath is at an azimuth of 227.2°. Image produced from ‘Horizon‘ Programme (copyright Smith 2020) using Terrain 50 data from Ordnance Survey under the Open Government Licence.

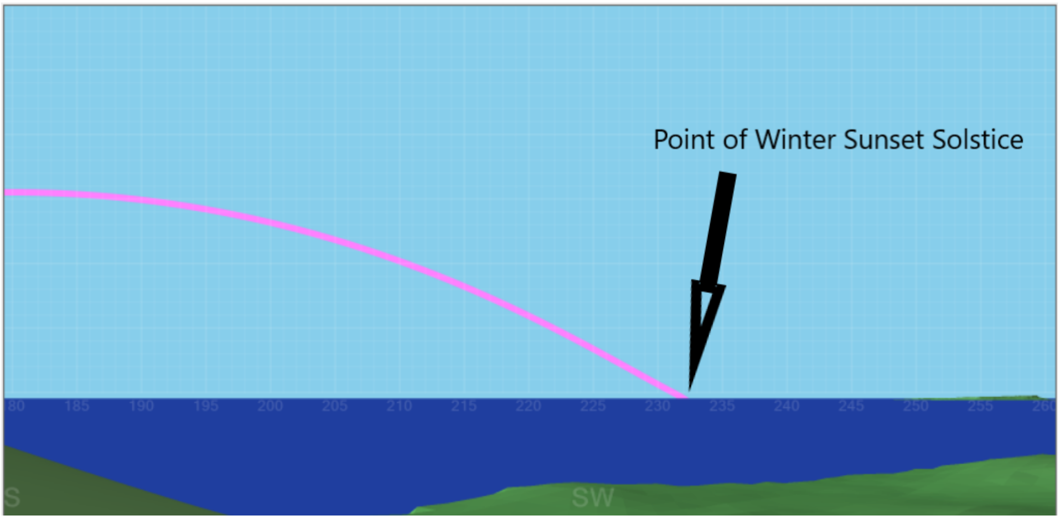

Figure 57 The position of the Winter Solstice Sunset in 2022, as seen from the barrow on Swyre Head is at an azimuth of 232° Image produced from 'Horizon ' Programme (Smith 2020) using Terrain 50 data from Ordnance Survey under the Open Government Licence.

A8.B. Measuring Declination

The value of the sine of the value of declination, where declination d is measured in degrees, of a point on the horizon is computed as:

sin d = sin h x sin L+ cos h x cos L x cos A

where h is the angular altitude of the point on the horizon (degrees above or below the horizontal plane as seen by the observer), L is the latitude of the site (in °), and A is the azimuth of the event on the horizon (in °) as seen by the observer. In the three examples illustrated, the calculations were carried out by using Smith's (2020) 'Horizon' programme, based on Ordnance Survey data (Terrain 50) , based on National Grid References (NGRs) of the sites. The calculations could have been carried out by hand, or in another programme, such as Ruggles's GETDEC (2023) or Silva's (2021) skyscapeR suite of programmes.

A8.C Obtaining information from which to calculate values of declination. Direct measurement of points on the horizon from pre-specified observation spots.

The first way of obtaining information from which to calculate values of declination is to directly measure values of the azimuth and angular altitude of points on the horizon as seen from a specified spot. The ‘specified spot’ , or rather, ‘pre-specified spot’, is important in order to promote a consistent, unbiased programme of measuring, that, for example, prevents observers from choosing spots which fit in with their preconceived beliefs, of which they may be unaware. The spots will be at a position at a predefined reasonable arbitrary distance from a part of the structure, usually in line with any observed axis of the structure (e.g., 10m distant from the end stone of a stone row, on the azimuth of the alignment extended from the row). The ‘reasonable specifications’ for a particular type of monument would usually come from preliminary fieldwork.

A8.D Equipment with which to make direct measurements of the azimuth and elevation of points on the horizon.

The values of azimuth and elevation can be measured in several different ways, each with their own strengths and weaknesses (Prendergast 2015, pp. 389-409). Measuring azimuth by using a hand-held prismatic compass in ideal conditions can achieve a precision of about 0.5° but may otherwise be about 1°. ‘Ideal conditions’ require applying a correction for deviations of magnetic north from true north, which vary over time and across locations, and also making measurements in both directions, from observing point to target and vice versa. A hand-held clinometer provides measures of angular altitude (from the horizontal) to a similar degree of precision. Theodolites can attain extremely high levels of accuracy of both azimuth and altitude, with validity under ideal conditions to several seconds of arc (c 0.01°). Electronic total stations are simpler to operate and provide similar levels of accuracy. Each of these can provide data from which to calculate a value of declination.

A8.E Making accurate measurements of the azimuth of points on the horizon.

When a theodolite or total station is set up, the directions of measurements taken from it mean nothing in absolute terms. Measurements of objects on the horizon can be made but are meaningless unless they are converted into measurements of their relationship with true North. The first step in this conversion is to identify the correspondence of measurements of azimuth made on the machine to that of true North. This can be obtained by firstly making a set of precise measurements of the azimuth of the sun, each made at a precisely measured time. The process of measuring the direction of North by making timed measurements of the azimuth of the sun ideally requires clear views of the sun for something like 30mins (Ruggles 1999, pp164-171 ; Kirch and Ruggles 2019, pp151-155). The actual azimuth values of the sun as seen from the observing position at those viewing times can be looked up from a source of exactly accurate astronomical data such as Nasa's 'Horizons' system (*The NASA Jet Propulsion Laboratory Horizons on-line solar system data and ephemeris computation service*). Once the azimuth of North from that observing point has been calculated it is possible to correct measurements of azimuth made on that day with equipment from that observing location. Thus, one can take a set of pairs of measurements of azimuth and angular altitude of a sequence of points on the horizon, convert the azimuth measurements into true values of azimuth , and then compute values of declination for those points. Ruggles's GETDEC programme (2023) and Silva's skyscapeR (2021) can also be used to compute declination from these data.

A.8.F Making indirect calculations of azimuth and elevation.

Sometimes it is impossible to make direct measurements, for example, because persistent weather conditions or visual barriers such as thick woodland render the horizon invisible. Ruggles (1999, p165) described using detailed maps and compass work to estimate azimuth and altitude by identifying on the map putative points on the horizon. Ruggles (1999) produced a programme (Set Dec) which could calculate apparent declinations from one grid reference to another . The subsequent development and availability of Geographical Information System (GIS) generic

programmes, such as ArcGIS (Esri 2023) and QGIS (qgis.org 2023), has made it easier to calculate and display on a map the area that can be potentially visible from the observer's position in good conditions, making this task easier. A helpful development is the dedicated 'Horizon' GIS Programme (Smith 2020) which generates images of the 360° view of the horizon potentially visible from a defined observation point, together with tables of detailed data, such as the values of angular altitude and declination for intervals of 0.01° of azimuth around the 360° horizon. The accuracy of this depends on the accuracy of the data it utilises. 'Horizon' has advantages, such as simplicity , and not having to visit sites, and the ability to produce data that are not

obscured by physical barriers.

A8.G Summary

This Appendix has summarised the key concept of declination and ways of measuring it. In the study described in this dissertation it was computed from (a) values of altitude for each 0.1° of the 360° horizon potentially visible from each of 142 specified viewing positions ('observation spots'), computed by Smith's *Horizon* programme (2020), when combined with information about the position (Latitude and Longitude) and elevation of each viewing position.

APPENDIX A9 TWO POTENTIAL LINES OF BARROWS INITIALLY PART OF STUDY THEN FOUND TO BE INAPPROPRIATE

Two groups of round barrows that were initially seen as meeting the requirements for the study, were found not to after visiting them.

Canford Heath Group

The OS map recorded a line of barrows on a south-west part of Canford Heath in Poole, and it was part of a Scheduled Group1018486 . LIDAR was not very clear .

After three visits I decided that I couldn't see a line of barrows, although I could see individual barrows in thick undergrowth .There was no persuasive mapping to look further.

Northport Heath Group

Three barrows form a Scheduled group at Northport Heath (1019147).

The Scheduling correctly describes the two westerly barrows as forming a twin bowl barrow, but for the study's purpose it was effectively one barrow, and the 'line' in effect was a pair of barrows, rather than three, and so it was not suitable to be a line of barrows.

Appendix A10

Basic Astronomical Factors in skyscape archaeology

A10.A Introduction

The essence of skyscape archaeology is the study of relationships between structures built in prehistory and the patterns of movement of the sun, moon, and stars. With the development of electric light most people in industrial nations are no longer familiar with these patterns of movement and so what was previously an everyday fact of life has become an area of specialist study. Even in the 19th Century this familiarity with celestial patterns was assumed by novelists such as Dorset's Thomas Hardy who described a shepherd estimating the time from the movement of the stars (in *'Far from the Madding Crowd'*) and expressed the horror of a soldier being buried in South Africa because they were beneath unfamiliar stars (in the poem '*Drummer Hodge'*). No such familiarity would be assumed by a popular author today.

Skyscape archaeology assumes that this everyday knowledge of the celestial patterns in a known landscape was part of the warp and weft of life and studies the relationships between structures and what was important to the people who made them. The aim of doing so is part of a wider endeavour to better understand these people. This area of study has developed in the last century, and a recent compendium of this, from all continents , filled a three-volume Handbook of 217 chapters, describing what was known then, a decade ago (Ruggles 2014). Much progress has been made even since then, so that skyscape archaeology is no longer an arcane art, but another specialist area of archaeology that archaeologists can draw from and contribute to. The basic methods of skyscape archaeology add information about the possible uses of structures, and sometimes adds to our understanding of the meaning attributed to the structures by those who built them.

The purpose of this Appendix is to summarise the key concepts in research in this area that contribute to answering the primary question of the current study. Section A provides a brief summary of the recurring patterns of the sun and moon and how it is possible to appreciate where those would have been seen from structures built in prehistory. Section B summarises how the concept of 'declination' helps archaeologists understand how those patterns could have been seen from structures in prehistory.

Section C describes how declination can be measured. Most of the examples described are from Britain.

Focussing on the extent to which prehistoric people built structures to 'point towards' solar and lunar events on the horizon does not to deny that other celestial questions are important. Other equally important types of questions on the linkage between monuments and celestial events require different methods to answer them. One such is the suggestion that upright components of East Scottish recumbent stone circles defined a 'screen' on which particular celestial events could be observed (Henty 2014). Another is the suggestion of meaningful interplay in the movement of solar shadows cast by sarsens in megalithic monuments at solstice sunrises (Meaden 2017). A third is the suggestion that the Thornborough henge complex in North Yorkshire was oriented towards the heliacal rising of the 'belt' in the star group of Orion during the late summer, and then that of Sirius in early autumn (Harding 2015, pp 1239-1248). Different types of questions need to be answered in different ways. The approach to methodology described here is appropriate to the question posed in the current study, , whether lines of round barrows 'point' towards solar and lunar events on the horizon, but not for all important questions in skyscape archaeology.

A10.B Common recurring celestial patterns

The celestial patterns most often studied by skyscape astronomy have been those involving the sun and moon and therefore this Appendix focusses on these. There are three aspects of the movement of the sun over the course of a year. The details of what can be seen vary with latitude. The further one moves away from the equator the lower degrees of latitude, so that some patterns visible in Shetland differ noticeably from those visible in Dorset.

A10.C The annual solar pattern. The sun has a daily pattern of rising in the east , rising higher in the sky towards the south until the middle of the day, and then dropping lower in the sky to set in the west. The duration of daylight follows this annual pattern from the shortest day in the year in mid December increasing through a day of equal day and equal night (the equinox, in March) through to the longest day in mid June. The days then gradually become shorter until there is another time of equal day and equal night (in September), and then returns to the shortest day in December. Another aspect of this pattern is the maximum height ('altitude') of the sun in the sky in a day. This is lowest in midwinter ('The winter solstice') and highest in midsummer ('The summer solstice').

The annual solar pattern is seen the duration of daylight, the position on the horizon of sunrise and sunset, and the highest point of the sun in the sky.

Astronomers have compiled information about the second-by-second movement of the sun throughout year that can easily be reached (e.g. from The UK HM Nautical Almanac Office (2024) or the NASA *Horizons* service (2024*)* Therefore, it is possible to identify where the sun will be seen to be at any moment from a defined spot on the Earth's surface, and the exact direction and time of its rise and set etc.

These basic patterns occurred in the past, although there are small long-term changes in the detail over the millennia. The sunset today is seen to set on the horizon approximately a couple of sun-widths from where it would have been seen from the same place in the Bronze Age. Knowing where extreme events (such as Midsummer sunset or Winter Solstice sunrise) would have been seen to occur from a particular spot at a specified time in the past allows us to understand what people then would have seen. Such knowledge is invaluable in assessing whether structures were built to offer views of specific events at a particular point in time. But skyscape archaeologists need to go a step further to measuring the position of views on the horizon that is independent from where one views them, and the key to this knowledge is the concept of 'declination', which is described below.

A.10.D The lunar pattern. Much that has been said about the pattern of apparent movement of the sun as seen from a position on the Earth's surface applies also to the apparent movement of the moon, although the moon appears to move more quickly, each month covering as much 'distance' as takes the sun to 'travel' in a year. Within about a month the moon can be seen to move from being fully invisible through to being fully visible as a disc. This approximately monthly pattern resembles the annual pattern of the sun, but a major difference is that the amount of the moon visible varies over the cycle, because, unlike the sun, it does not emit it's own light, but reflects what is available from the sun (which varies according to how much the earth passes between the moon and the sun). The invisible moon has no sunlight to reflect: the full moon reflects the full sunlight.

The moon also has an additional long-term pattern of variation, on an 18.6-year cycle. This is shown by where the moon appears to slow down and 'stop' on its monthly cycle (a bit like the way the sun appears to stop at the solstices on its annual cycle) .The positions where the moon appears from the earth to slow down and stop, on its this 18.6-year cycle varies between two extremes 9.3 years apart, the 'minor lunar limit' and the ‘major lunar limit’. These phenomena have also been called the ’lunar limits’ and the ‘lunastices’ .

If one looks from the same point each day on a wide clear horizon, one can track the slow movement of, for example, the sunset over the course of a year. The sunset moves from a point in the south in the winter to one in the north during the summer, and, to our eyes, oscillates between these two extreme positions each year. The pattern varies imperceptibly from year to year (although it does move slowly over the centuries) (Figure 46).

Figure 58 The Winter Solstice and Summer Solstice sunset points on the horizon from the Winter Solstice in the South to the Summer Solstice in the North (personal collection 2024).

The moon follows a different pattern, which is easier to grasp if one regards the positions of the solstices as sign posts on the horizon. From a fixed point of earth, each month (approximately) the moon appears from the Earth to move between two points, and these apparent stopping points, drift very slowly over time. The stopping points drift gradually outwards, till they rest beyond the solstice points, then pause briefly , and then move inwards for 9.3 years until they slow down and ‘rest’ at an opposite position between the Solstice ‘sign posts’. This set of limits appears from Earth to be outwith the annual track of travel of the sun. (Fig 57)

Figure 59 The Major Limits of the Moon , where the moon appears to cease travelling further outwith the Winter Solstice and Summer Solstice sunset points on the horizon. After a relatively short apparent pause it appears from Earth to start travelling back towards and within the positions of the Solstices (personal collection 2024).

After several months, the moon appear to follow a pattern in which it travels less far out each month until, 9.3 year later, it slows down and settles again briefly, at apparently inward spots. 'Inward' means that the moon is seen from the earth to rise and set between the apparently fixed points at which the sun rises and sets at the solar solstices. After a pause the moon appears to start travelling progressively outwards again, and to slow down and stop doing so at an extreme position beyond the positions of the solstices (the 'Major Limits'). The pausing points apparently within the Solstices are called the 'Minor Limits' (in Figure 58) are within the positions of the two solstices.

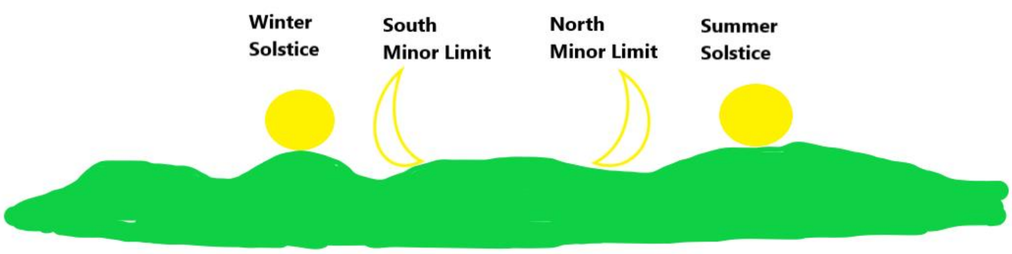

Figure 60 The Minor Limits of the Moon , where the moon appears to cease travelling further while between the Winter Solstice and Summer Solstice sunset points on the horizon. After a relatively short apparent pause it is seen from Earth to start travelling back towards and eventually beyond the positions of the Solstices (personal collection 2024).

In travelling outwards beyond the apparent positions of the solstices the moon sets and rises in positions in the sky to which the sun never travels. If one can anthropomorphise heavenly objects , it is as though the Moon sets on land forbidden to the Sun.

There is claimed to be an association between lunar standstill events and the occurrence of solar eclipses, and also other events such as increased risk of flooding on earth. Studies of the latter identify which types of shore are more likely to experience flooding, according to what researchers describe as ‘18.6-year nodal flooding’ (e.g. Haigh *et al* 2011; Thompson *et al* 2021). The lunar standstill events are more easily seen by people who live in a fixed place with a good view of the areas of the horizon where the standstills occur. These patterns of events offer cultures a marvellous opportunity onto which to project their beliefs, especially as they recur over 18.6 years, the time it takes to develop from birth to adulthood. Researchers into the relationship between prehistoric structures and lunar standstill report that they can be observed in an 11th Century AD Pueblo Culture structure in Colorado (Malville 2016). Gonzalez-Garcia, and Belmonte (2019) pointed out the conceptual and practical difficulties in studying this and suggested that the recumbent tombs in Aberdeenshire is another type of site where lunar standstills could be observed.