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Population level models for testing hunter-gatherer resilience and settlement response to the combined impact of abrupt climatic events and sea level change: a case study from the Holocene of northern Britain.

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ABSTRACT

Isolating the impacts of abrupt climatic events on Holocene hunter-gatherers from those of gradual environmental change is methodologically challenging and conflicts with the lived experience of Mesolithic communities for whom the world was in continuous flux. We explore the combined impacts of abrupt climate events (ACEs) and gradual sea level change on the Mesolithic communities of northern Britain by using a summed calibrated probability distribution (SCPD) of radiocarbon dates as a population proxy, addressing sources of potential bias, including the history of research, differential site destruction, calibration effects and changes in settlement pattern. Our study is placed into a European context by reviewing studies that have reached contrasting conclusions about the impacts of ACEs on Holocene hunter-gatherer communities. We suggest such differences arise from variation in their specific ecological settings, cultural repertoires, and social environments, concluding that Holocene hunter-gatherers in northern Britain were especially vulnerable to environmental change.

KEY WORDS

Holocene hunter-gatherers, abrupt climate events, sea level change, northern Britain

INTRODUCTION

As Quaternary scientists, we partition the study of Holocene environmental change into distinct categories, such as changes in temperature, precipitation, vegetation, and sea level, often reconstructing each in relative isolation to the other. Similarly, we distinguish between gradual environmental change and abrupt climatic events (ACEs) and seek to test the resilience of past population to the latter (e.g., González-Sampériz et al., 2009; Wicks & Mithen, 2014; Blockley et al., 2017). Methodologically this is challenging because ACEs occurred in the context of gradual environmental change and separating the impact of one from the other is problematic (Robinson et al., 2013; Crombé, 2018). Moreover, it is likely that Mesolithic communities experienced their environment in a holistic manner, one of constant flux on a daily, seasonal, annual, and generational basis, and hence seeking to identify their resilience and/or response to one or more of our imposed categories is contrary to their lived experience, although often a pragmatic necessity for research.

In this contribution we seek to explore the combined impact of gradual sea level change and ACEs on Mesolithic communities in northern Britain. Building on our previous studies (Wicks & Mithen, 2014; Waddington & Wicks, 2017), we construct and interrogate a summed calibrated probability distribution (SCPD) of radiocarbon dates as a population/settlement pattern proxy for northern Britain between 10.6 Ka BP and 5.8 Ka BP, defining this region as north of the 50° latitude (Figure 1).

SCPDs have provided an innovative methodology for addressing population change, transforming our use of the archaeological record (e.g., Gamble et al. 2005; Shennan & Edinborough, 2007; Buchanan et al., 2008; Shennan et al., 2013). Their use assumes that larger numbers of people will generate more radiocarbon samples; when those samples are combined into a single calibration curve, its peaks are taken to reflect relatively high population levels and its troughs the converse. SCPDs as population proxies have, however, come under severe criticism, noting how factors unrelated to past population levels such as research methodologies, differential site preservation, calibration effects and change in settlement patterns can bias the distribution of dates within SCPDs (e.g., Surovell & Brantinghman, 2007; Williams, 2012; Contreas & Meadows, 2014; Crombé & Robinson, 2014; Attenbow & Hiscock, 2015). We address these biases, which were insufficiently considered in our previous work (Wicks & Mithen, 2014; Waddington & Wicks, 2017) and remain neglected in current studies (e.g., Lewis et al., 2020, Petraglia et al., 2020).

Our period of study covers the entire extent of hunter-gatherer settlement in northern Britain, prior to the replacement of Mesolithic communities by incoming Neolithic farmers at c. 5.8 Ka BP (Saville, 2004; Brace et al. 2019). There were three ACEs during this period, at 10.4-10.2, 9.3 and 8.2 ka BP (Rasmussen et al., 2007; Wang et al., 2013). Indicators for their environmental impact include changes in chironomid frequencies in lake sediments and in the vegetation in NW England, western Scotland, and Ireland (O'Connell & Molloy, 2005; Edward et al., 2007; Lang et al., 2010; Wicks, 2012; Ghilardi & O'Connell, 2013; Wicks & Mithen, 2014). Sea level rise in northern Britain began at c. 9.3 Ka BP and reached a maximum for the main postglacial shoreline between 7.4-7.9 and 6.2-6.4 BP, with a relative sea level rise of between *c.* 7m and 12m (Smith et al., 2012), the variation reflecting distance from the area of greatest glacio-isostatic uplift (Figures 1 and 2). Rather than being gradual and continuous, sea level rise occurred in four episodes, each marked by a culmination followed by a fall, while also showing regional variation (Smith et al., 2012). The drainage of Lake Agassiz at 8.47 Ka BP caused one such jump, amounting to an additional 2.11 ± 0.89m within 200 years over the on-going background relative sea level rise (Himja & Cohen, 2010). That might itself be considered an abrupt event. Another was the Storegga tsunami of 8.15 Ka BP (Weninger et al., 2008) that had a maximum run-up of c. 20m above contemporary sea level on Shetland and 3-6m in NE Scotland (Bondevik et al., 2005). Northern Britain was, to say the least, a dynamic environment for Mesolithic communities.

Prior to building our model, we place this case study into context by briefly reviewing current research on the impact of ACEs and sea level change in Mesolithic Europe.

Testing population resilience to abrupt climatic events

Considerable attention has been paid to the impact of the 9.3 ka and 8.2 ka ACEs in Europe but with quite different conclusions. González-Sampériz et al. (2009) argued that aridity at 8.2 Ka BP caused the abandonment of settlements in NE Spain, while Wicks & Mithen (2014) concluded that reduced temperatures and increased storminess had a devastating impact on the Mesolithic population of western Scotland. Robinson et al. (2013) identified important sociocultural and technological changes in the Rhine-Meuse-Scheld region at 9.3 ka BP and 8.2 Ka BP but were reluctant to attribute causation to these abrupt cooling events. Conversely, Breivik et al. (2018) concluded the 8.2 Ka ACE had no impact on the costal settlement of Norway, while Griffiths & Robinson (2018) argued for settlement continuity across the 8.2 ka BP event throughout NW Europe. Similarly, Blockley et al. (2017) argued that an ACE at 11.1 ka BP, equivalent in its severity to that at 8.2 ka BP, had no impact on early Mesolithic hunter-gatherers as represented at Star Carr.

Why are there such contrasting conclusions? Three reasons can be proposed. First, is simply the challenge of accumulating environmental and archaeological data sets that have sufficient chronological resolution and can be linked in a causal chain of evidence to the impact of ACEs, as represented in geographically distant ice cores. As noted by Robinson et al. (2013) and Crombé (2018), ACEs occurred in the context of gradual environmental change and separating out the impact of one from the other is problematic.

Second, is the strong likelihood of variation across Europe in both the environmental impact of such events and of hunter-gatherer resilience – there is no *a priori* reason to expect a consistent pattern across NW Europe. Hunter-gatherers in ecologically diverse localities are likely to have been more resilient that those dependent on a narrow range of resources; those in coastal regions would have had the additional impact from sea level change. Social and cultural variation between Mesolithic communities is also likely to have been an influence. The technological repertoire of Mesolithic hunter-gatherers in southeast Norway, for instance, included grinding slabs ground-pecked adzes, pressure flaking and indirect percussion to make blades (Breivik et al., 2018). This technology may have enabled the communities to sustain the environmental impact of the 8.2 ACE in a manner that was not possible with the more limited technology found in Mesolithic western Scotland (Saville 2004). Hunter-gatherer population histories, densities, and social networks at the time of the ACEs will have also varied and influenced the extent of their resilience. By the time of the 8.2 BP ACE, hunter-gatherers had been in Norway for over two millennia with established populations, extensive environmental knowledge, and social networks (Breivik et al. 2018). This contrasts with the relative newcomers to western Scotland, whose first presence dates to 10.2 ka BP and who may not have been permanently present in the region until 9.2 ka BP (Mithen et al. 2019).

Third, is a contrast in the methods used to evaluate resilience to ACEs, some of which might be less robust than others. For instance, we question the validity of Blockley et al.'s claim (2017) that the Star Carr community – by which we assume they mean the mobile hunter-gatherer group that made use of the lake-edge at Lake Pickering – was resilient to the 11.1 ka BP ACE because Blockley et al. drew on evidence from a single site, Star Carr itself. Activity might have persisted at Star Carr while the population and regional settlement pattern became significantly disturbed. Indeed, Star Carr is precisely the type of site where activity may have continued during periods of environmental stress by this locality providing a resource-rich refuge and because of its use for ritual activity (Conneller, 2004; Chatterton, 2006) – a type of behaviour liable to increase during periods of stress (Hayden, 1987). Similarly, we remain cautious about both the attempt and value of identifying 'persistence of occupation' at individual sites, as undertaken by Griffiths & Robinson (2018). That approach might be appropriate for sedentary communities such as Neolithic farmers but appears problematic for mobile hunter-gatherers. Their sample of 89 sites with 245 radiocarbon calibrations seems insufficient for generalising about the whole of northwest Atlantic Europe. We readily concur with Griffiths & Robinson (2018), however, regarding the challenges of using summed calibrated probability distributions (SCPDs) of radiocarbon dates as population proxies because of either unforeseen or unaddressed biases they often encompass, as in our own previous work– that we now address.

Resilience to sea level change

Although the extent of postglacial sea level change has long been recognised, its impact on Mesolithic communities has received surprisingly limited study and is also a subject of contrasting views. Sea level rise can have positive impacts on hunter-gatherers by increasing the extent of resource-rich inter-tidal areas and providing new routes of travel by expanding sea ways (Barnett et al., 2020). Lewis et al. (2020) attributed population growth in Scandinavia to the high levels of marine productivity that arose from a combination of sea level rise and increasing temperature. More generally cultural complexity in the late Mesolithic of southern Scandinavia has been closely linked to the exploitation of marine and coastal resources (e.g., Larsson, 1990; Boethius et al., 2021).

Conversely, the negative impacts of sea-level rise have also been noted and tend to be emphasised in projections for future sea level rise: salt-water inundation, the erosion of beaches and the loss of tidal flats (Glick et al., 2007; Holle et al., 2019). For both past and future sea level rise these impacts disturb invertebrate, fish, bird, and sea mammal communities; they destabilise food-webs with consequences for hunter-gatherer resource availability. Benjamin et al. (2017) noted that sea level rise in the Mediterranean Basin flooded coastal sites, displaced fishing and shell fishing grounds, creating isolated environments in the form of new islands, bays, and straits, while Barnett et al. (2020) described the increased vulnerability of insular and island communities arising from sea level rise. In northern regions, where isostatic rebound was significant, the fall in relative sea level may have had equivalent environmental and economic impacts.

As with the impacts of ACEs, that of relative sea level change would have been highly variable throughout Europe, depending on the balance of eustasy and isostasy, coastal topography, ecological diversity, and reliance of hunter-gatherers on coastal and marine exploitation. The initial stages of sea level rise may have simply shifted coastal habitats inland, with limited impact on hunter-gatherer foraging opportunities especially when this was gradual development within low-lying coastal plains. In some locations, however, thresholds would have been reached where topography prevented the further ingress of such habitats resulting in their loss and reduction of the hunter-gatherer resource base. Localised environmental events, such as tsunamis and storm surges would have exacerbated the impact of gradual sea level rise, as evident from modern-day studies (Ramachandran et al. 2005; Urabe et al. 2016). As with the impact of ACEs, we should not expect to find continental or even regional consistency in the impact of relative sea level rise on Mesolithic communities because of localised variation in their ecological and cultural context.

EARLY HOLOCENE HUNTER-GATHERER COMMUNITIES IN NORTHERN BRITAIN

There is sparse evidence for a human presence in northern Britain prior to 10.4 Ka BP. Traces of Late Upper Palaeolithic activity at Howburn (Ballin et al., 2018) and Rubha Port an t-seilich (Mithen et al., 2015) appear to reflect short-term events rather than sustained occupation. Although Mesolithic communities were established south of the 50^{o} latitude by 11.5 Ka BP, as represented at Star Carr (Milner et al., 2018), there are few traces of their diagnostic 'broad blade' microliths in the north, and none that are associated with radiocarbon dates.

Marine inundation of the North Sea basin at c. 10.4 Ka BP appears to have been a trigger for the dispersal of people into northern Britain from Doggerland who utilised a distinctive technology with small geometric narrow blade microliths (Waddington, 2015). This technology spread throughout Britain, replacing the earlier broad blade microliths, and was only supplanted by incoming Neolithic farmers at or soon after 5.8 Ka BP (Brace et al., 2019; Garrow et al., 2017; Whittle et al., 2010). Throughout this period, Mesolithic communities were reliant on hunting, gathering, and fishing. Economic data from northern Britain is sparse and insufficient to detect change over time. That available suggests a mixed economy of hunting red deer, roe deer and wild boar (e.g., Woodman, 1985; Finlay et al., 2002; Warren, 2005; Waddington, 2007; Wicks et al., 2014; Mithen et al., 2015), exploiting hazelnuts and a diversity of plant foods (e.g., Mithen et al., 2001; Bishop et al., 2013) and an extensive use of coastal and marine resources (e.g., Mellars, 1987; Wicks & Mithen, 2017). The topographic distribution of sites ranges from coastal locations (e.g., Oronsay, Mellars, 1987; Morton, Coles et al. 1971) to those in the highlands (e.g., Caochanan Ruadha, Warren et al., 2018). We interpret this data as indicating mobile communities with mixed economies, involving terrestrial, coastal, and marine resources.

The study region of northern Britain is approximately, 100,000 Km^2. Considering the ethnographically documented size of hunter-gatherer territories and population densities (Kelly, 2013, Tables 4.1, 7.3) this is likely to have encompassed several hunter-gatherer communities, most likely connected into one or more alliance networks. Although ethnographic analogies are problematic, we are drawn to comparison with Canadian boreal woodland hunter-gatherers such as the Mistassini Cree and Waswanipi Cree, whose total annual territories are given as 3,385 and 4,870 Km^2 respectively, suggesting population densities of between 0.4 and 1.4 persons 100/ Km^2 (i.e., 400-1400 persons for northern Britain). Site distributions (Figure 1), the topography of the landscape, and the attraction of coastal and estuarine environments to hunter-gatherers, suggest an east-west partition of the total population, with community connections dominated by north-south rather than east-west relations.

METHOD

The data base and SCPD

To build our SCPD we collated all radiocarbon dates from northern Britain falling between 10.6 to 5.8 Ka BP. We drew on the datasets in Wicks & Mithen (2014) for western Scotland, Waddington & Wicks (2017) for eastern northern Britain, Ashmore (2004) for sites in northern Britain omitted by those studies, recent publications (notably Dingwall et al. (2019) and Wickham-Jones et al. (2021)), and unpublished dates. All dates either had been or were audited to remove those with possible contamination, and which could not be confidently associated with human activity. By imposing a cut-off at 5.8 Ka BP we excluded any dates that might relate Neolithic activity, the first traces of which occur after this date in northern Britain (Garrow et al., 2017; Whittle et al., 2010)

Our audited dataset contains 439 samples coming from 87 sites – increasing the number of dates and sites used in our previous studies by 46% and 24% respectively, with the dates having an average standard deviation of 52.81 (Supplementary data; Figure 1). The 87 sites are a small but indeterminate fraction of known Mesolithic sites in the region, the majority lacking any radiocarbon dates. The SCPD was derived using the SUM command in Oxcal. As specified in our supplementary data, 225 of the samples were on charred hazelnut shell fragments, 165 on wood charcoal, 24 on bone from terrestrial mammals and 9 on antler. These were calibrated using IntCal20. Twelve dates were on shell and were calibrated with Marine20.14 using local marine reservoir correction factors drawn from Cappelli & Austin (2020) and Harkness (1983), as specified in supplementary data. Four dates were on human bone from middens on Oronsay, (Caisteal non Gillean II and Cnoc Coig) and were given a mixed terrestrial and marine calibration (following Schulting & Richards, 2002).

Controlling for bias

As noted above, the use of SCPDs as population proxies have been criticised for encompassing several sources of unacknowledged bias in the distribution of radiocarbon dates. We address these as follows:

Bias arising from cultural variation in the generation of potential radiocarbon samples: Different types of societies and economies will generate different quantities of material suitable for radiocarbon dating irrespective of the numbers of people. It is reasonable to assume, although yet to be demonstrated, that person for person, sedentary societies will generate larger quantities of organic waste than will mobile hunter-gatherers, whether from collapsed timber structures, centralised waste disposal or craft activities. In addition, such organic waste from sedentary communities is likely to be deposited within well-defined contexts suitable for radiocarbon dating in contrast to the characteristic palimpsests of waste found on hunter-gatherer settlements (Crombé & Robinson, 2014). We avoid this problem by restricting ourselves to the Mesolithic period within which we have no *a priori* reason to believe there was behavioural change that influenced the rate of deposition of potential samples for radiocarbon dating. We will, however, address variation in settlement pattern when interpreting the SCPDs.

Bias arising from variation in research methodology: Some archaeological periods have a greater representation in the radiocarbon record than others because these have been especially targeted by research projects (Crombé & Robinson, 2014). This does not apply to our study area because research projects have been geographically rather than chronologically driven, either at specific sites (e.g., Mount Sandel, Woodman, 1985; Howick, Waddington, 2007), on islands (e.g., Oronsay, Mellars, 1987) or in regions (e.g., southern Hebrides, Mithen, 2000; Inner Sound, Hardy et al. 2009). Mesolithic sites have also been found during rescue archaeology in advance of development projects (e.g., Milltimbers, Dingwall et al. 2019). We have no reason to believe this history of research will have biased the radiocarbon record to one or more phases of the Mesolithic.

Bias arising from the multiple dating of single sites: There is a marked variation in the numbers of radiocarbon dates coming from single sites: 110 (25%) of our 439 dates come from just four (4.6%) sites: (Howick, 33; Mount Sandel, 27; Chest of Dee; 26, Criet Dhu, 24). Eleven sites have greater than 10 dates while 22 sites are represented by a single date. This variation largely arises from history of research: the reduced cost and greater accuracy of radiocarbon dating, along with increased appreciation that Mesolithic sites are predominately palimpsests, has increased the propensity for multiple dating: nine of the 11 sites with >10 dates were published after 2000, while all 22 of those with a single date were published prior to 2002. Similarly, there is a negative correlation between the date of publication and size of standard deviation of radiocarbon dates ($R^2 = 0.43$).

To control for this variation, we establish the minimum number of activity events represented by the radiocarbon dates from each site, with each activity event represented by a set of statistically consistent radiocarbon dates (Table 1). We assign the date of the activity event to the median of the calibrated 95% range of the combined date. Within our data set, for instance, the 33 dates from Howick fall into three statistically consistent groups (with medians at 10,038, 9719 and 9285 BP) and hence might represent no more than three short term uses of that location, while the 14 dates from Rubha-Port an t-Seilich represent a minimum of eight events. These are, however, only the minimum number of events: each event might represent multiple visits within a time frame that cannot be separated by the uncertainties of the radiocarbon dating. For instance, the three activity events at Howick have 95% ranges of 279, 294 and 325 years. Overall, our sample of 439 radiocarbon dates represent a minimum of 202 activity events.

Our use of activity events also mitigates bias arising from how variation in the nature and availability of fuel and the uses of fire influence the quantity of charcoal created from single burning events at hunter-gatherer sites (Attenbrow & Hiscock, 2015).

Rather than combining the statistically consistent dates from each site into a single date for use within our SCPDs, we prefer to maintain use of the complete data set and compare the SCPD against a histogram of activity events measured at 300-year intervals through time. That interval was selected as an approximation to the average duration of the 202 activity events (282 years, 95% confidence level, Table 1). We also record the number of radiocarbon dates within each time slice, enabling comparison of that with the number of activity events they represent.

Bias arising from the size and environmental diversity of study region: Hunter-gatherers were not evenly distributed across the landscape. If a study area is too small, it is unlikely that a representative sample of the population will be secured by the archaeological coverage, as in Blockley et al. (2017). Moreover, it is often difficult to secure a sufficiently large sample of radiocarbon dates from a relatively small region. This has been recommended to be at least 200 for a time interval of 0-14 Ka BP years for data sets have a mean standard deviation of 115 (Williams, 2012; Michczynńska & Pazdur, 2004). Continental scale models (e.g., Gamble et al. 2005; Shennan & Edinborough, 2007; Attenbow & Hiscock, 2015) have access to large data sets but risk creating a blurred signal: a flat SCPD might be masking population increase in one region which is contemporaneous with decrease elsewhere. While this might be of no consequence when considering gross population changes, models for exploring the impact of sea level rise and ACEs need to be developed at a geographical scale that is meaningful to hunter-gatherer subsistence and settlement activity.

We divide northern Britain into the east and west (Figure 1). This reflects our understanding that each Mesolithic community had accessed terrestrial, coastal, and marine resources with scales of mobility equivalent to those documented in the ethnographic record for analogous environments. The contrasting weather conditions between the two areas, with the west being wetter, colder, and windier than the east, suggest differential rates of fertility and mortality and hence contrasting population dynamics. Our partition into east and west creates approximately equal sample sizes: the east represented by 43 sites, 232 samples with a mean standard deviation of 45.16, and 104 activity events; the west by 44 sites, 207 samples with mean standard deviation 61.39, and 98 activity events (Supplementary data; Table 1).

Bias caused by the calibration curve: Natural variations in the concentration of atmospheric carbon over time has resulted in significant plateaus in the calibration curve for radiocarbon dates. A well-known consequence is a reduction in the precision of calibrated date ranges of ^{14}C determinations falling across flattened sections of the calibration curve. The plateaus occurring across the Pleistocene-Early Holocene transition are particularly pronounced, these increasing the gradient of the calibration curve immediately preceding the plateaus. Such slope steepening influences the post-calibration shape of posterior density functions generated by pooled ^{14}C data sets, which can result in the generation of tall narrow peaks. To the inexperienced these can be misinterpreted as representing variability in the ^{14}C proxy for past human activity (Williams, 2012; Contreas & Meadows, 2014), especially when changes in population or activity might be expected because of climate/environmental change.

A means to control for this is by simulating SCPDs from uniform distribution to compare with the archaeological SCPD (e.g., Bamforth & Grund, 2012). We generated ten simulated SCPDs, covering the same chronological range as the data set, composed of the same number of ^{14}C samples (n = 439) and randomly drawn from a uniform distribution, each with the standard deviation of the mean of the archaeological dataset (52.81). The simulated SCPDs are then compared against that generated from the real data set. We did likewise for the east and west samples, using the range, size, and standard deviations of those data sets. In addition to using simulated SCPDs, our use of histograms of activity events will provide a further check on the impact of calibration effects (Williams, 2012).

Bias caused by landscape change: Environmental change can result in the differential preservation and discovery of archaeological sites through time resulting in a biased distribution of radiocarbon dates. A consequence of sea level rise is that sites from prior to its maximum height are likely to be under-represented in the archaeological record, some remaining submerged offshore, others destroyed by the rise and then fall in sea level or buried by sediment. The maximum rise in sea level was between 7m and 12m and hence we might estimate the degree of underrepresentation from the distribution of the 69 activity events that post-date the maximum transgression at c. 7.0 Ka BP that are located below these levels, and hence would have been lost from earlier periods – assuming settlement patterns were consistent with that post 7.0 Ka BP. Eight (11.59%) of the post-7.0 Ka BP activity events are below 7m and 28 (40.58%) below 12m. Consequently, if settlement patterns in the earlier Holocene were consistent with those post 7.00 Ka BP, we might expect that between 12% and 40% of sites will have been lost, the frequency depending on the extent of rise of relative sea level rise. That loss would have been most severe in areas where there was a gently sloping coastal shelf and the landscape is riven with estuaries, known to be favoured locations for hunter-gatherer settlements. While there is no reason to expect different degrees of bias between the east and west arising from relative sea level rise, the east coast of northern Britain was also subject to the Storrega tsunami event at c. 8.15 Ka BP (Weninger et al. 2008). Its run-up reached c. 20m above contemporary sea level on Shetland and 3-6m in NE Scotland (Bondevik et al., 2005). Local topography is likely to have reduced its destructive power from that previously proposed (Walker et al., 2020).

In addition to sea-level change and the Storrega tsunami, erosion and sediment deposition from storm events, the growth of peat, and the shifting of sand dune deposits will have destroyed some and buried other sites, most likely having a greater impact on those of an older age and hence reducing their representation in the archaeological record (Surovell & Brantingham, 2007; Surovell et al. 2008; Attenbrow & Hiscock, 2015). Farming, forestry, and recent settlement can also impact on the survival, discovery, and likelihood of excavation of Mesolithic sites, destroying some sites while enabling the discovery of others (e.g., Dingwall et al., 2019). While the extent and impact of such factors will be variable across northern Britain, there is no a priori reason to think they will have been more significant in the west and east areas of our study area.

Bias caused by changes in human mobility and settlement pattern: The number of archaeological sites created and the likelihood of their preservation and discovery depends not only on the absolute number of the population but how people are distributed in the landscape. Hunter-gatherers are known to have diverse mobility and settlement patterns, creating different types of archaeological records (e.g., Binford, 1980). This arises from adaptive responses to the distribution of resources within the environment, enabling semi-sedentism when resources are naturally replenished, which primarily occurs in coastal or riverine settings (Kelly, 2013). Low degrees of residential mobility will create a relatively small number of large settlements and numerous small task-specific locations that might be archaeologically invisible, while high degrees of residential mobility will result in a larger number of medium sized archaeological sites. Because Mesolithic sites are rarely, if ever, fully excavated estimating their size, range of activities and the number of occupants is a persistent challenge. Moreover, in our study region the size of a settlement bears no relationship to the number of radiocarbon dates available. The spatially small settlement of Rubha Port an t-Seilich, for instance, has 14 radiocarbon dates, while the vast expanse of Mesolithic debris at Bolsay has a mere two radiocarbon dates, this difference reflecting the research aims and available resources of the excavations when undertaken (20 years apart in 1992 and 2013 respectively, Mithen, 2000; Mithen et al., 2015). Considering the environmental changes during the Mesolithic, including those of temperature, sea level, vegetation, and resource distribution, we should expect mobility and settlement patterns to have varied throughout this period, which might confound attempts to estimate population levels from the numbers and distributions of archaeological sites and radiocarbon dates, whether measured by SCPDs or activity events. As such, we will address evidence for settlement change when interpreting the shape of the SCPDs.

RESULTS

Northern Britain. Figure 2 illustrates the archaeological SCPD for northern Britain against a histogram of the numbers of activity events, numbers of radiocarbon dates, simulated SCPDs, and indicators of sea level change.

Between 10.4 Ka BP and 9.0 Ka BP, the shape of the SCPD closely matches that of the 10 simulations that draw on random distributions of dates. The SCPD peak centred on 10.3 Ka BP coincides with those of the simulations and should be considered an artefact of the calibration curve rather than a proxy for population levels. The next SCPD peak is centred on 9.6 Ka BP and occurs immediately prior to that of the simulations at 9.5 Ka. In this case we see a mismatch between the height of the SCPD peak and the low number of activity events in the time periods of 10.0 - 9.7 Ka BP (n=5) and 9.7 – 9.4 Ka BP (n=7). Those 12 activity events (5.94% of the total) come from 10 sites but are represented by 89 radiocarbon dates (20.27% of the total), including statistically consistent sets of 24 from Howick, 14 from Fife Ness and 27 from Mount Sandal – each representing just one activity event. We note, however, that these activity events have 95% ranges of 325, 97 and 39 years respectively and hence might encompass a sequence of activities that cannot be distinguished between by the radiocarbon dates. Nevertheless, the increased height of the SCPD prior to its 9.6 Ka BP peak appears to be primarily an artefact of the number of radiocarbon dates within the model, which is then exacerbated by a calibration effect at 9.5 Ka BP.

The trough in the SCPD between 9.3 and 9.0 Ka BP closely matches that in all simulations, suggesting this is also artefact of the calibration curve. That is also indicated by its contrast with the increase in the number of activity events between 9.4-9.1 Ka, represented by a relatively low number of dates (n=27, 6.15% of total). The SCPD then diverges from the simulations to reach a plateau between 9.0 and 8.6 Ka BP, this rise matched by the increase and then sustained high levels of activity events in the same timeframe. Sea level was also rising throughout this period and consequently we might expect 12-40% of sites to have been lost by either submergence or destruction if the overall site distribution by altitude was consistent with that post 7.0Ka BP.

After 8.6 Ka BP, the SCPD falls, reaching a low at 8.2 Ka BP, where it remains until 7.0 Ka BP. This has a different shape to the simulations indicating that radiocarbon dates are fewer in this time interval than we would expect by chance. The histogram of activity events has a similar shape, reaching its low point of six events between 7.9-7.6 Ka BP. After 7.0 Ka BP, the SCPD climbs to a new plateau and the number of activity events steadily increase to the imposed boundary at 5.8 Ka.

One of the striking patterns in Figure 2 is the lack of correspondence between declines in the SCPDs that occur at 9.5Ka BP and from 8.6 Ka BP and the timing of the abrupt climatic events of 9.3Ka BP and 8.2Ka BP. Might this, however, arise from a blurring of regionally specific population dynamics and biases on the radiocarbon record?

Eastern Northern Britain. Figure 3 illustrates the archaeological and simulated SCPDs for the east, against the activity event histogram. In comparison to the SCPD for the whole of northern Britain, the peak at 10.2 Ka BP remains, reflecting a relatively early Mesolithic presence in the east although the calibration effects suggest it is unlikely to have been centred at 10.2 Ka BP itself. The rise in the archaeological SCPD after 10.0 Ka BP now lacks the influence of the Mount Sandel dates (located in the western region) and might be more confidently related to changes in extent or character of human activity other than for the spike centred on 9.5Ka BP which is an artefact of calibration. The time interval between 10.6 and 9.1 Ka BP contains 23 activity events in the east, representing 74.19% of those for this time interval for the whole of northern Britain.

The archaeological SCPD falls at 9.3Ka BP, coincident with the ACE. This may, however, be an artefact of the calibration curve because the number of activity events continue to increase, reaching a plateau of 10 events for each of the 300-year time slices between 9.1 and 8.5 Ka BP. This is within the period of rising sea level that might have destroyed/submerged sites, while others might have been lost by the Storegga event.

The SCPD shows a dramatic decrease at 8.5Ka BP. This cannot be explained as an artefact of the calibration curve because the pattern is matched by a decline in activity events from ten between 8.8 and 8.5 Ka BP to four between 8.5 to 8.2 Ka BP, recovering to seven between 8.2 and 7.9 Ka BP, and then falling to a single activity event for the period 7.9-7.6 Ka BP. Neither does this decline at 8.5 Ka BP correlate with any known climatic oscillation. It does, however, coincide with the Lake Agassiz drainage that caused a sudden jump of sea level. The combined impacts of rising sea level and the Storegga event may have caused the loss or archaeological sites, but a 40% compensation still leaves these at a relatively low level throughout his period. After 7.4 Ka BP, the SCPD increases, as does the histogram of activity events, reaching eleven events between 6.1-5.8 Ka BP.

Western Northern Britain. Figure 4 illustrates the archaeological and simulated SCPDs for the west, against the activity event histogram and numbers of radiocarbon dates. The region has just two activity events between 10.6 and 9.7Ka BP in contrast to the 12 in the eastern region, supporting Waddington's (2005) proposition of colonisation of northern Britain from the east). The representation of the two activity events in the SCPD by a peak at 10.2 Ka BP is most likely an artefact of the calibration curve. The next peak at 9.6 Ka is offset from the 9.5 peak in the simulated SCPDs, with its position and height reflecting the large number of dates from a single site (Mount Sandal) that represent just one activity event (with a 95%-time range of just 39 years). After 9.3 ka BP, there is a rise in both the SCPD and number of activity events to a peak at 8.2Ka BP, despite the likely loss of sites arising from sea-level rise throughout that period. A fall in both the SCPD and the number of activity events coincides with the 8.2Ka BP event. Both the SCPD and the histogram remain at low levels until c. 7.0 Ka BP, before gradually increasing to new peak between 6.1-5.8 Ka BP.

INTERPRETATION

The 87 archaeological sites representing 202 activity events provide a small fraction of known Mesolithic sites within the study region, the indeterminate remaining number lacking radiocarbon dates. While the number of samples available for the east (n= 232) and west (n=207) are statistically viable, combining them to make a more robust model is intuitively attractive. We have shown, however, that this conflates differences in the SCPDs and activity event distribution from the east and the west. Having controlled for variation in site preservation and multiple dates from single sites and being confident that the dataset is not biased by research history that may have focussed on one period of the Mesolithic than another, there are two frameworks for interpreting the shape of the SCPDs and the histograms of activity events in Figures 2, 3 and 4: variation in population levels and variation in mobility. We will as initially consider the former, and then explore whether a demographic interpretation is challenged or confirmed by changes in settlement patterns.

Population dynamics.

Following a sporadic late glacial and pre-10.4 Ka BP presence, a colonisation event occurred at *c*. 10.4 Ka BP arising from the inundation of North Sea basin. This brought Mesolithic groups with narrow blade technology into what is now the eastern area of northern Britain, represented by sites of Cramond, east Barnes and Echline Fields, with a swift dispersal into the west, represented by activity events at Dear Reservoir 1 and Criet Dhu (Figure 1; Table 1). A severe calibration effect constrains inferences as to whether these sites form a tight chronological cluster or were more dispersed throughout the late 11th millennium BP, while there is insufficient activity within this time interval to identify any impact of the 10.2 Ka BP ACE.

After colonisation and initial dispersals, the chronological change in the shape of the SCPDs and histogram of activity events can be interpreted as reflecting significant differences in the population dynamics of the east and the west regions. While both areas experienced population growth after 10.0 Ka BP, this appears to have occurred earlier in the east, reflecting the founding population. We are unable to find any strong evidence that the population in the east was impacted by the 9.3 Ka BP ACE while being unable to dismiss this posisbility because inferences are constrained by calibration effects. The 9.3 Ka BP ACE was not significant in the west because its population numbers remained at low levels.

Interpreting the SCPD as a population proxy indicates a significant decline in population in the east at 8.5 Ka BP, coinciding with the Lake Agassiz drainage that caused a sudden jump of sea level. We suspect the potential loss of archaeological sites by sea level rise and the Storegga event are insufficient to explain the decline at 8.5 ka BP and are attracted to the destabilisation of coastal and marine ecosystems caused by sea-level rise passing a critical threshold that prevented the further inward migration of coastal habitats, this reducing resource availability and constraining human populations to a relatively low level. We suspect the on-going destabilisation of marine and coastal habitats by relative sea level rise was exacerbated by the Storegga tsunami, these maintaining populations at low densities.

The initial rise and then jump in sea level at 8.5 Ka BP does not appear to have impacted on population growth in the west. We suspect this reflects local topography whereby the more fragmented coastline of this region enabled continued coastal exploitation for longer than in the east, with a critical destabilising threshold of relative sea level rise only occurring after 8.2 Ka BP, this coinciding with the 8.2 ka BP ACE. Their combined impact caused a population collapse: colder temperatures, stormier weather, the loss of coastal foraging opportunities will have reduced fertility and increased mortality of both infants and adults. Despite the likelihood of some sites having been destroyed by sea-level rise, we infer the population remaining low until 7.0 Ka BP, throughout the period of sea level rise.

Both the east and west have a similar shape in their SCPDs and activity event histograms after 7.0 Ka BP. We interpret this as a reflecting the growth of populations throughout the region following cessation of sea-level rise and the stabilisation of coastal and marine ecosystems, along with increased site preservation. This occurs at a similar time to the population growth in the Danish Mesolithic that is attributed to high levels of marine productivity (Lewis et al. 2020). The 5.8 Ka BP boundary was imposed to mark the earliest presence of Neolithic communities in northern Britain after which Mesolithic sites are extremely rare, suggesting the rapid replacement of a demographically fragile hunter-gatherer population.

Settlement patterns.

Might changes in hunter-gatherer mobility and the settlement patterns of a numerically stable population provide an alternative interpretation for the shape of the SCPDs and activity event histograms? This would require the troughs in the SCPD to reflect periods of reduced mobility with a smaller number of larger settlements than found during the peaks in the SCPD. To explore this, we divide the post 9400 BP dataset into three periods of equal duration: 9400-8200 BP, 8200-7000 BP and 7000-5800 BP – the period prior to 9400 ka BP is not considered because this has a small sample size and patterns will also be confounded by process of colonisation. The second of our three periods, 8200-7000 BP, covers the trough in the SCPD (Figure 1), which we have interpreted as a period of low population. Might this period be one of low mobility and hence with a smaller number of larger settlements, created by a Mesolithic population that remained numerically stable throughout the Holocene?

Because few, if any, sites have been excavated in their entity, it is not possible to test whether spatially more extensive sites reflecting large populations are found within the period 8200-7000 BP. An alternative measure of mobility is the number of activity events per site: if mobility has been reduced, we would expect that a smaller number of sites would have been used more frequently for the period between 8200-7000 BP. Our data set, Figures 5, suggests the converse: between 9400-8200 BP, there are 75 activity events occurring at 44 sites, with an average of 1.76 events per site. In the following period, this falls to an average of 1.34 events/site (39/29), which implies an increase rather than decrease in mobility during the SCPD trough. Between 7000-5800 BP, there are 1.57 events/site (69/44), suggesting a decrease in mobility.

Such changes in mobility are supported by the distribution of substantial structures at Mesolithic sites – circular, post-built huts that imply a significant investment in the location either for a long period of occupation or in the knowledge of repeated visits. Such structures are known from only five sites in our study area: Howick, Echline Fields and East Barnes in the east, and from Mount Sandel and Credit Dhu in the west. These structures, some described as 'pit-dwellings' have been proposed as evidence for semi-sedentism (Waddington et al., 2007, for Howick; Gooder, 2007, for East Barnes; Robertson et al., 2013 for Echline) or repeated use of favoured places (Mithen & Wicks 2019). These five sites provide 97 (22.01%) of the radiocarbon dates and 12 (5.94%) of the activity events of the data set. All these dates and events occur, however, prior to 8200 BP, suggesting an increase rather than decrease of mobility during the period 8200-7000 BP that covers the trough in the SCPD.

A third measure of mobility derives from the topographic distribution of activity events. Figure 5 illustrates the distribution of activity events for each of our three time periods in relation to elevation, summarised in Figure 6. In both the east and west regions, the majority of sites/activity events are below 50m OD for all three chronological periods. There is, however, a substantially higher frequency of sites/activity events above 100m OD between 8200-7000 BP (30.77%) than is found in both the preceding (13.33%) and the following (13.04%) periods, with this most notable for the east region (42.86%, as opposed to 21.88% and 13.89%). There is no reason to think that a higher number of sites at lower elevations have been lost for the 8200-7000 BP period than for 9400-8200 BP – as noted above both are likely to have lost between 12% and 40% of their sites due to sea level change, and one would expect taphonomic loss to have been more intense for the earlier period. As such, we can be confident that the increase in the frequency of activity events at higher elevations between 8200-7000 BP reflects a change in settlement pattern. The shift to higher elevations accords with the inference for both higher mobility and a lower population because coastal resources are recognised as sustaining relatively high population levels and reduced mobility amongst hunter-gatherers (Kelly, 2013).

In summary, three lines of evidence – the ratio of activity events to site numbers, the presence of structures, and activity event distribution by elevation – suggest higher degrees of hunter-gatherer mobility between 8200-7000 BP than in the preceding (9600-8200 BP) and the following period (7000-5800 BP) of the Mesolithic. Had the absolute population numbers remained the same, higher mobility would have increased the number of activity events and created a peak rather than a trough in the SCPD during 8200-7000 BP. Because we observe the converse, this confirms the proposed reduction of population, that we attribute to the combined impacts of sea level rise, the 8.2 Ka event in the west, and the Storegga event in the east.

CONCLUSION

Gradual sea level change and abrupt climatic and environmental events had a severe impact on the demography of Mesolithic communities of northern Britain. The timing and nature of the impact differed between the east and the west: while communities in both areas were impacted by destabilisation of coastal ecosystems caused by sea level rise, those in the east were more susceptible to the jump in sea level at 8.5 ka and experienced the Storrega event, while those in the west were impacted by the 8.2 ka BP ACE that coincided with sea level rise reaching a critical threshold. These contrasts arose from differences in their settlement histories and local topography. In both areas, the numerically reduced population responded by increasing mobility involving a greater use of higher elevations. They both returned to a more coastally focussed settlement pattern following the cessation of sea level change, and population growth resumed prior to demographic replacement by incoming Neolithic migrants at or soon after 5.8 Ka BP.

Although passing the threshold of viability, our sample sizes for radiocarbon dates from the east and the west remain smaller than desirable, with the possibility that new discoveries and new dates may change the shape of the SCPDs and/or distributions of activity events. We note that the increased number of dates for eastern northern Britain, from the 163 used by Waddington & Wicks (2017) to our sample of 232, has modified the shape of the its SCPD (compare Waddington & Wicks 2017, figure 4 and our Figure 3), although there has been minimal change to the western SCPD arising from a similar increase of dates (from 137 by Wicks & Mithen 2014 figure 5, to 207 in this study, Figure 4) – other than that from the inclusion of Mount Sandal arising from expanding the geographical scope of the west (from Scotland the northern Britain). With the larger sample sizes, we are confident that both the eastern and western SCPDs are now relatively robust. Nevertheless, more archaeological data would be welcome. Moreover, our proposals regarding the impact of sea level rise need to be further considered by detailed modelling of changes in coastal topography and site distributions. Consequently, we present our conclusions primarily as hypotheses for further testing by new radiocarbon dating programmes, archaeological fieldwork and paleoenvironmental reconstruction.

Our conclusions maintain the contrast between northern Britain and other regions in Europe regarding hunter-gatherer-resilience to environmental change. That such variation exists should not be surprising because hunter-gatherer communities adapted to local ecological conditions, with varying cultural repertoires, settlement histories and social networks. Northern Britain was one of the last regions in Europe to be colonised following deglaciation, leaving its population at a relatively low density and potentially without the long-established social networks and environmental knowledge enjoyed by communities elsewhere before the onset of relative sea level rise, early Holocene ACEs and the storegga event.

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FIGURE CAPTIONS

Figure 1. Northern Britain, showing the location of archaeological sites used in this study, the demarcation into the west and the east, and location of the sea level curves illustrated in Figure 2.

Figure 2. Comparison of climate anomalies, relative sea level rise, activity events, radiocarbon dates and SCPD for northern Britain, 10.6 – 5.8 Ka BP.. (a) CISSC05 δ^{18}O isotope curve (after Svensson et al. 2008); (b) Relative sea level curves for Western Forth Lowlands and Morecambe Bay, as located on Figure 1 (after Smith et al. 2012); (c) Activity events and numbers of radiocarbon dates, drawing on Table 1; (d) Archaeological SCPD (shaded) and ten simulated SCPDs of randomly distributed dates, drawn from a uniform distribution with the same parameters as the archaeological SCPD.

Figure 3. Comparison of activity events, archaeological and simulated SCPDs for eastern northern Britain, 10.6 – 5.8 Ka BP.

Figure 4. Comparison of activity events, archaeological and simulated SCPDs for western northern Britain, 10.6 – 5.8 Ka BP.

Figure 5. Activity event distributions by elevation in northern Britain for 9.4-8.2, 8.2-7.0 and 7.0-5.8 Ka BP.

Figure 6. Frequencies of activity events by elevation for 9.4-8.2, 8.2-7.0 and 7.0-5.8 Ka BP.

TABLE CAPTION

Table 1. Activity events for northern Britain 10.6 - 5.8 Ka BP
(See supplementary data for site references, sample information and calibration)

SUPPLEMENTARY DATA

Radiocarbon samples for northern Britain, c. 10.6 – 5.8 Ka BP

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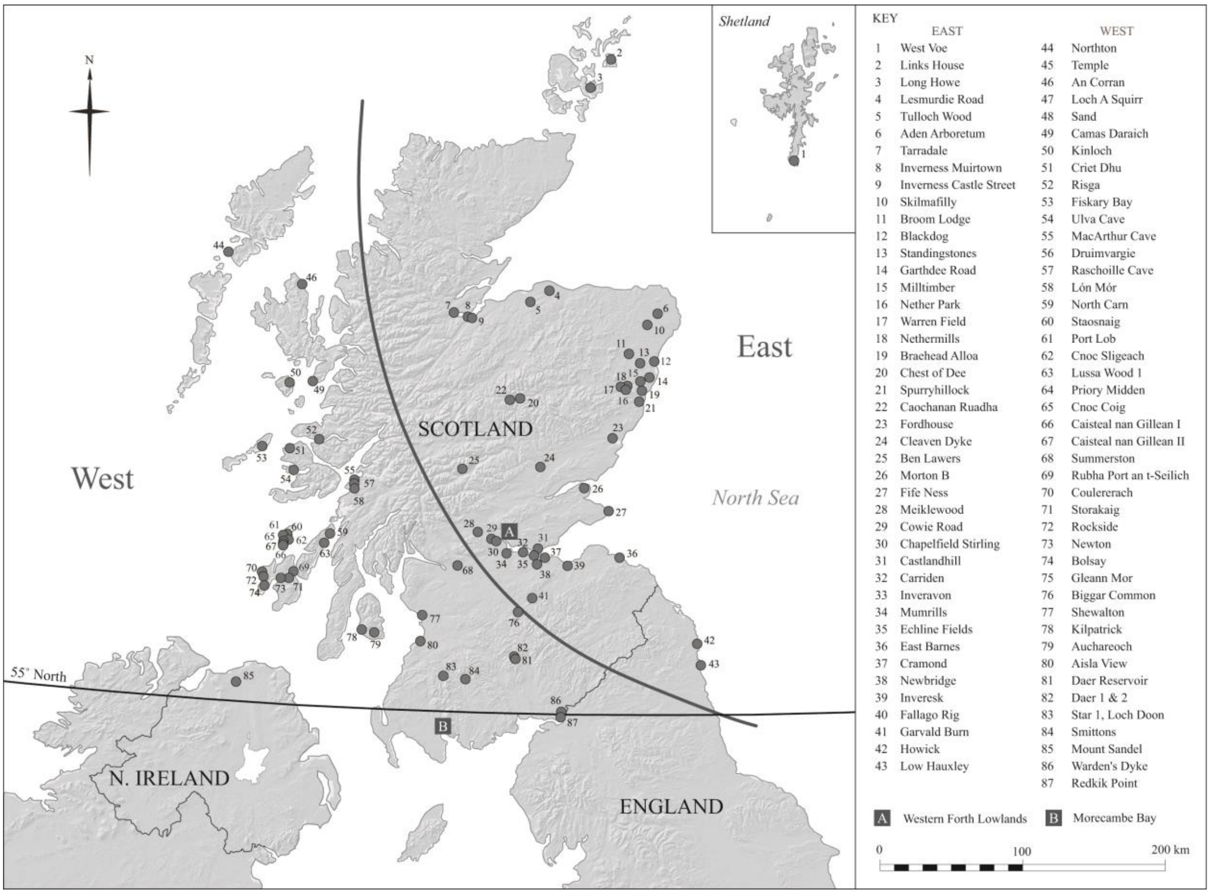

Figure 1. Northern Britain, showing the location of archaeological sites used in this study, the demarcation into the west and the east, and location of the sea level curves illustrated in Figure 2.

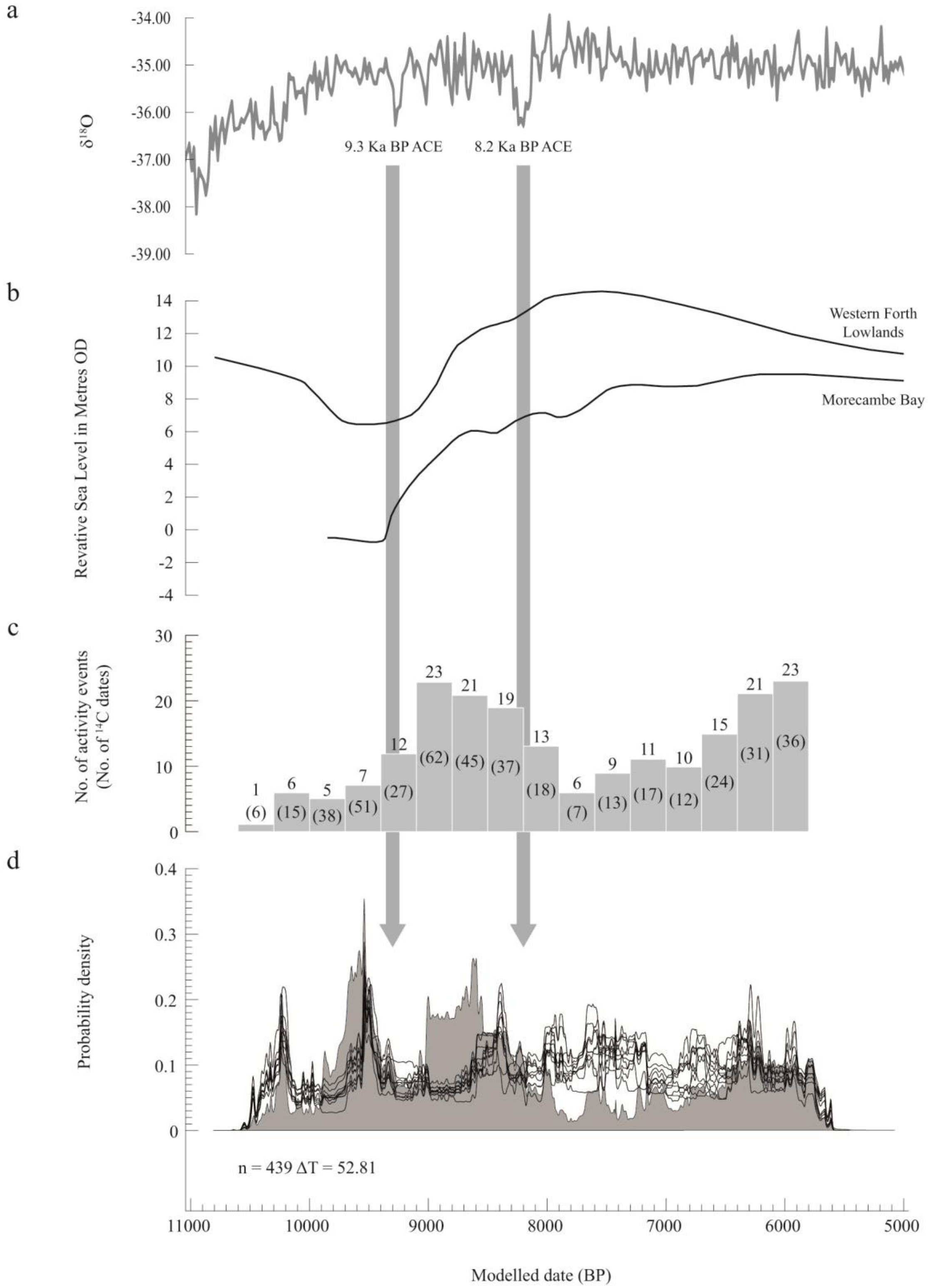

Figure 2. Comparison of climate anomalies, relative sea level rise, activity events, radiocarbon dates and SCPD for northern Britain, 10.6 – 5.8 Ka BP.. (a) CISSC05 $\delta^{18}O$ isotope curve (after Svensson et al. 2008); (b) Relative sea level curves for Western Forth Lowlands and Morecambe Bay, as located on Figure 1 (after Smith et al. 2012); (c) Activity events and numbers of radiocarbon dates, drawing on

Table 1; (d) Archaeological SCPD (shaded) and ten simulated SCPDs of randomly distributed dates, drawn from a uniform distribution with the same parameters as the archaeological SCPD.

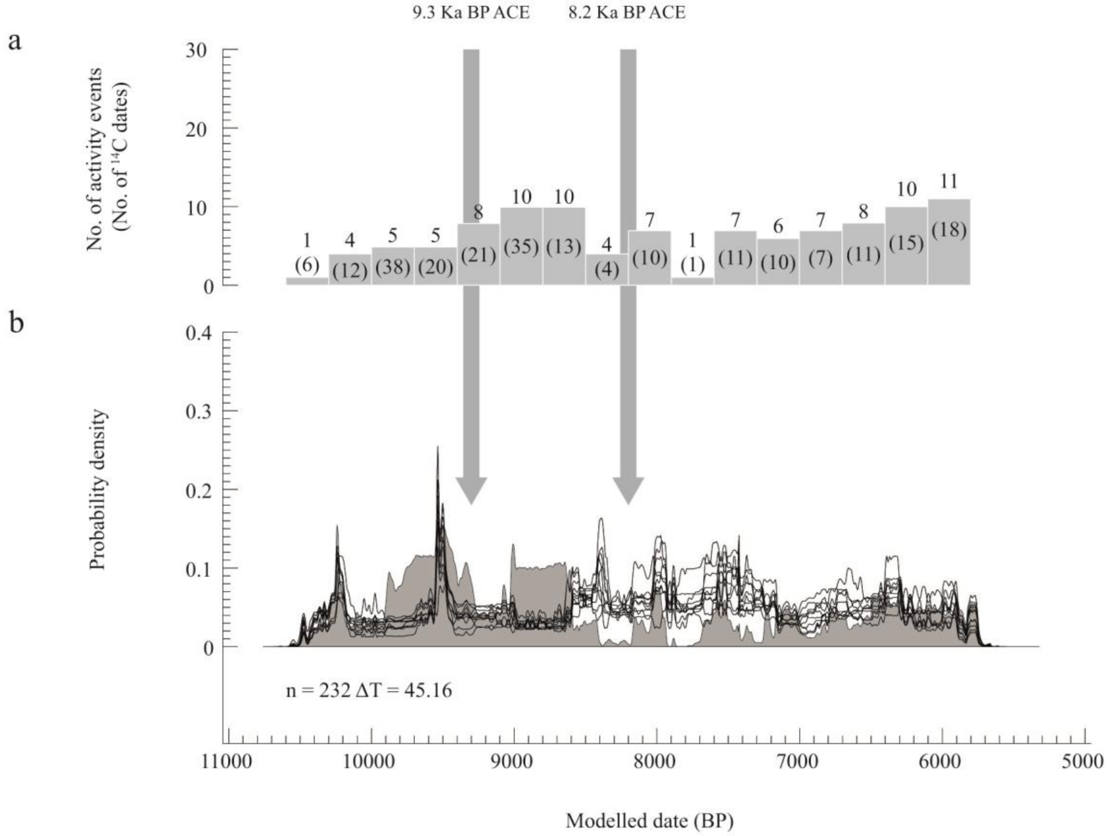

Figure 3. Comparison of activity events, archaeological and simulated SCPDs for eastern northern Britain, 10.6 – 5.8 Ka BP.

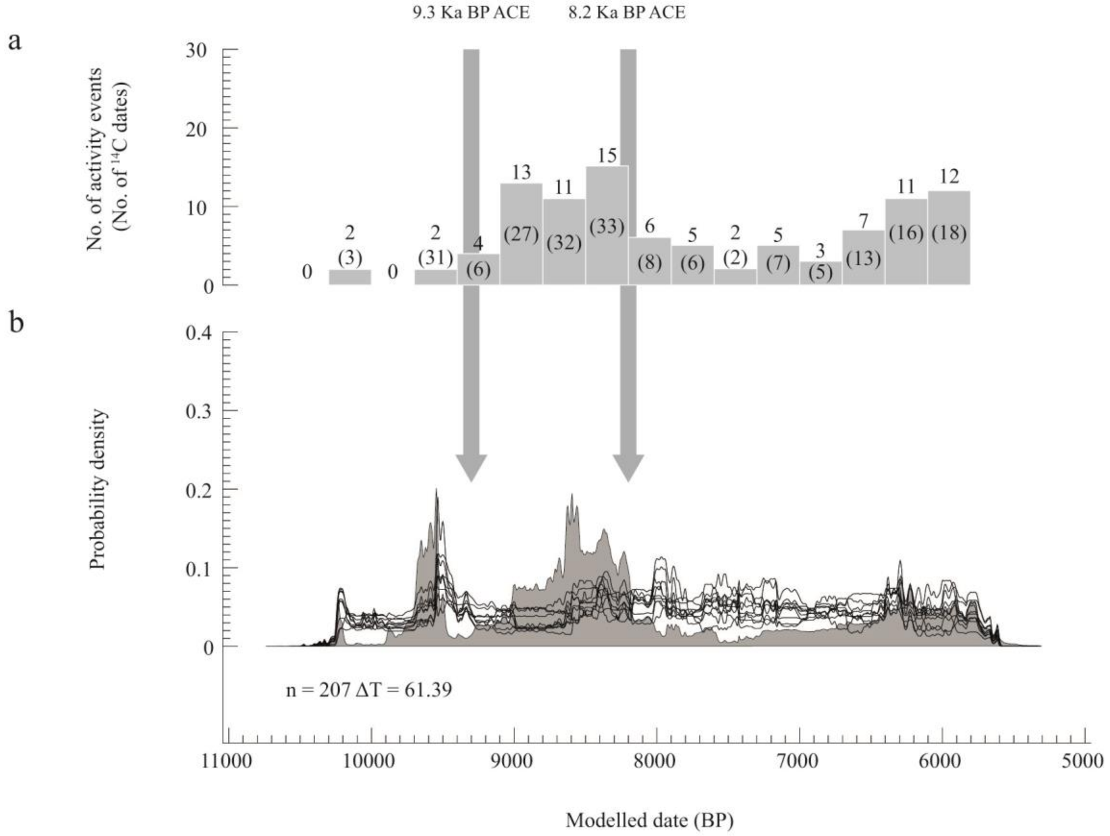

Figure 4. Comparison of activity events, archaeological and simulated SCPDs for western northern Britain, 10.6 – 5.8 Ka BP.

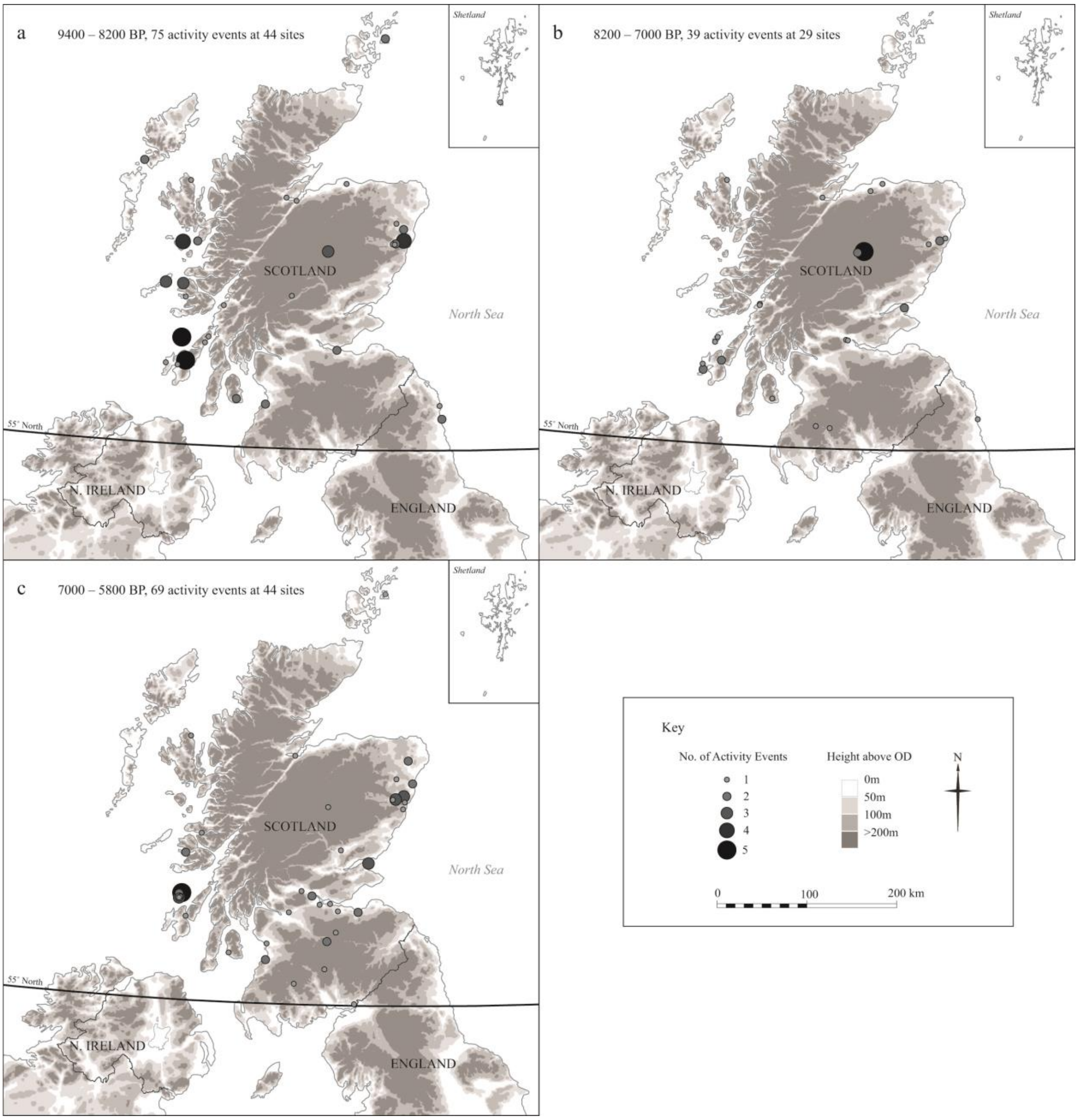

Figure 5. Activity event distributions by elevation in northern Britain for 9.4-8.2, 8.2-7.0 and 7.0-5.8 Ka BP.

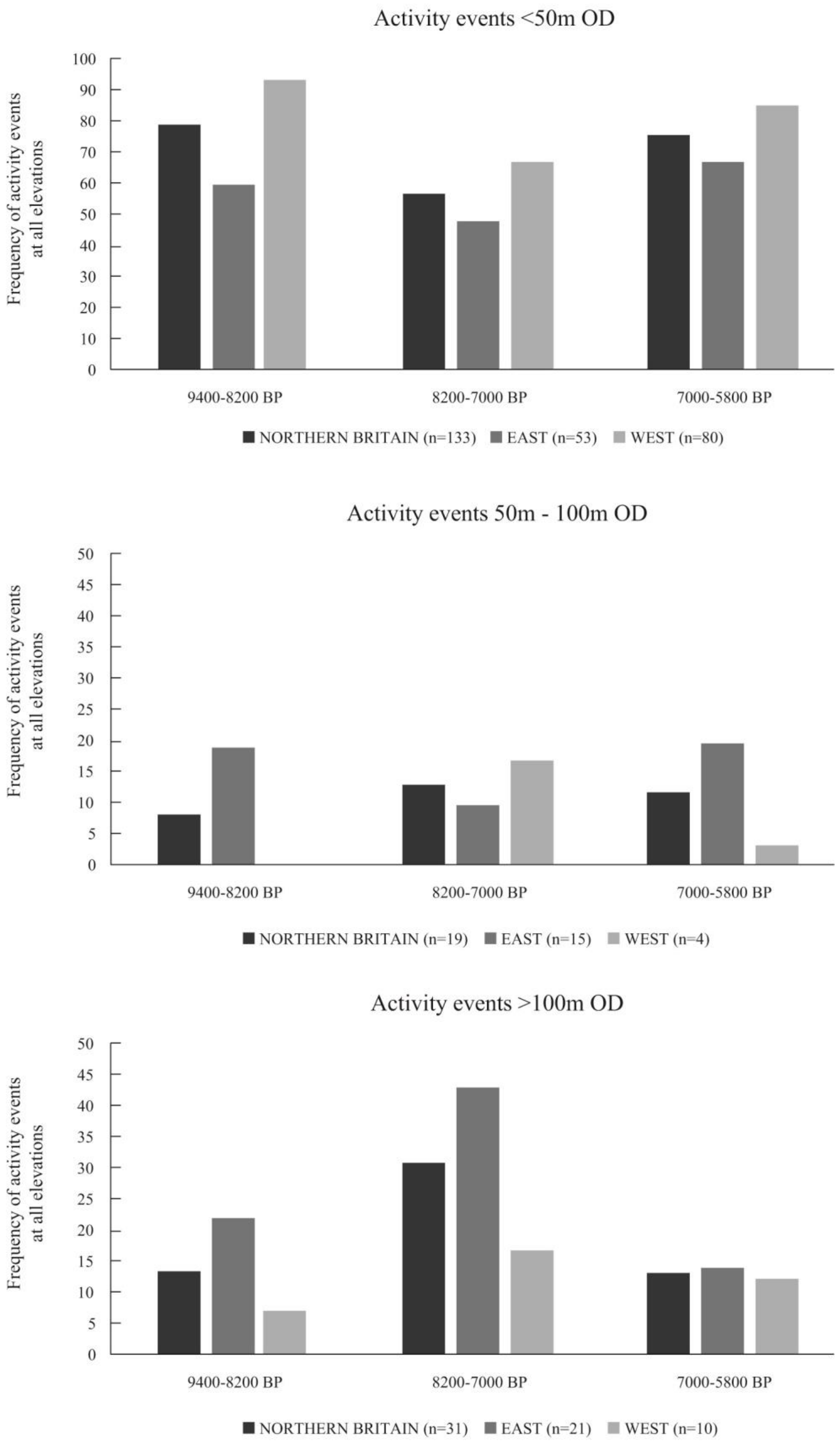

Figure 6. Frequencies of activity events by elevation for 9.4-8.2, 8.2-7.0 and 7.0-5.8 Ka BP.

Table 1. Activity events for Northern Britain 10.6 - 5.6 Ka BP
(See supplementary data for site references, sample information and calibration)

				95% confidence range			
Site		**Dates**	**T Test**	**Start**	**End**	**Range**	**Median**
Cramond	E	OxA-10143 (9150, 45) OxA-10145 (9230, 50) OxA-10144 (9110, 60) OxA-10180 (9250, 60) OxA-10178 (9105, 65) OxA-10179 (9130, 65)	df=5 T=5.8 (5% 11.1)	10,478	10,242	236	10,360
Echline Fields	E	SUERC-39769 (9060, 35) SUERC-39764 (9075, 35) SUERC-39761 (9080, 40) SUERC-39760 (9095, 35) SUERC-42919 (9123, 28) SUERC-39759 (9130, 35) SUERC-42918 (9145, 30)	df=6 T=5.6 (5%12.6)	10,285	10,224	61	10,255
Criet Dhu	W	SUERC-58137 (9070, 29) Beta-288421 (9080, 40)	df=1 T=0.0 (5% 3.8)	10,249	10,197	52	10,223
Daer Reservoir 1	W	AA-30354 (9075, 80)		10,496	9919	577	10,208
Chest of Dee	E	SUERC-58528 (8977, 29)		10,233	9924	309	10,079
Howick	E	OxA-12402 (8885, 65) OxA-11829 (8890, 45)	df=1 T=0.0 (5% 3.8)	10,185	9891	294	10,038
MIlltimber	E	SUERC-68106 (8848, 29) SUERC-68101 (8897, 29)	df=1 T=1.4 (5% 3.8)	10,162	9893	269	10,028
East Barnes	E	AA-54962 (8835, 65) AA-54960 (8985, 70) AA-54961 (8830, 70)	df=2 T=3.3 (5%, 6.0)	10,183	9785	398	9984
Low Hauxley	E	SUERC-49878 (8812, 32) SUERC-49891 (8843, 32)	df=1 T=0.5 (5% 3.8)	10,122	9781	341	9952
Warren Field	E	SUERC-10076 (8710, 40) SUERC-10075 (8755, 40) SUERC-10077 (8765, 40) SUERC-12266 (8850, 40)	df=3 T=6.4 (5% 67.8)	9899	9630	269	9765
Low Hauxley	E	SUERC-49893 (8677, 32) SUERC-49883 (8711, 32) SUERC-49892 (8733, 32) SUERC-49873 (8767, 34) SUERC-49890 (8789, 32)	df=4 t=7.6 (5% 9.5)	9885	9555	330	9720

Howick	E	AA-41788 (8555, 60) OxA-11826 (8630, 40) OxA-11855 (8650, 45) OxA-12294 (8690, 40) OxA-11827 (8700, 45) OxA-12347 (8710, 38) OxA-11854 (8710, 45) OxA-11831 (8715, 45) OxA-11830 (8715, 50) OxA-12327 (8725, 39) Beta-153650 (8730, 40) OxA-11801 (8734, 37) OxA-12324 (8739, 39) OxA-12325 (8739, 39) OxA-11857 (8750, 45) OxA-11802 (8754 38) OxA-11803 (8763, 38) OxA-12326 (8765, 40) OxA-11832 (8780, 45) OxA-12292 (8785, 40) OxA-11828 (8785, 45) OxA-11856 (8785, 45) OxA-11853 (8790, 45) OxA-11804 (8802, 38)	df=23 T=33.3 (5% 35.2)	9881	9556	325	9719
Mount Sandel	W	UB-7038 (8678, 41) UB-7029 (8658, 44) UB-7030 (8594, 44) UB-7033 (8660, 44) UB-8137 (8680, 44) UB-7031 (8684, 45) UB-7036 (8636, 45) UB-7037 (8645, 45) UB-7034 (8647, 47) UB-8871 (8681, 49) UB-7032 (8631, 50) UB-6852 (8674, 51) UB-6853 (8682, 51) UB-6855 (8569, 51) UB-8139 (8757, 51) UB-6844 (8697, 52) UB-6848 (8608, 52) UB-6851 (8502, 52) UB-6854 (8578, 52) UB-8138 (8566, 52) UB-6842 (8672, 53) UB-6843 (8775, 53) UB-6845 (8699, 53) UB-6847 (8724, 53) UB-6856 (8672, 53) UB-6849 (8644, 54) UB-6850 (8645, 55)	df=26 T=34.0 (5% 38.7)	9678	9639	39	9659
Milltimber	E	SUERC-68096 (8620, 29) SUERC-54050 (8657, 29)	df=1 T=0.8 (5% 3.8)	9678	9537	141	9608
Chest of Dee	E	SUERC-75306 (8598, 34)		9678	9493	185	9586
Kinloch	W	GU-2150 (8310, 150) GU-2040 (8560, 75) GU-1874 (8515, 190) GU-1873 (8590, 95)	df=3 T=2.6 (5% 7.8)	9597	9435	162	9516
Chest of Dee	E	SUERC-74125 (8497, 31)		9539	9470	69	9505
Warren Field	E	SUERC-10082 (8460, 40) SUERC-10078 (8530, 40)	df=1 T=1.5 (5% 3.8)	9538	9471	67	9505

Fife Ness	E	AA-25203 (8340, 60) AA-25205 (8405, 60) AA-25206 (8355, 60) AA-25210 (8410, 60) AA-25215 (8490, 60) AA-25202 (8275, 65) AA-25207 (8420, 65) AA-25212 (8545, 65) AA-25213 (8495, 65) AA-25214 (8510, 65) AA-25208 (8510, 70) AA-25204 (8505, 75) AA-25209 (8475, 75) AA-25211 (8460, 85)	df=13 T=19.0 (5% 22.4)	9528	9431	97	9480
Low Hauxley	E	SUERC-49880 (8306, 32) SUERC-49882 (8350, 32) SUERC-49888 (8351, 32) SUERC-49887 (8402, 32) SUERC-49881 (8418, 32) SUERC-49877 (8419, 32)	df=5 T=10.2 (5% 11.1)	9473	9311	162	9392
Lesmurdie Road	E	Poz-5490 (8350, 50) Poz-5492 (8320, 50)	df=1 T=0.2 (5% 3.8)	9469	9148	321	9309
Milltimber	E	SUERC-68100 (8313, 30)		9443	9143	300	9293
Howick	E	OxA-11807 (8233, 36) OxA-11806 (8278, 35) OxA-12293 (8280, 40) OxA-12322 (8310, 40) OxA-11805 (8324, 37) OxA-12408 (8330, 45) OxA-12323 (8355, 39)	df=6 T=7.0 (5% 12.6)	9424	9145	279	9285
Druimvargie	W	OxA-4608 (8340, 80)		9527	9038	489	9283
Fordhouse Angus	E	OxA-10059 (8255, 55)		9421	9029	392	9225
Aisla View	W	SUERC-2395 (8240, 40)		9405	9028	377	9217
Rubha Port an t-Seilich	W	Beta-288426 (8230, 40) Beta-288427 (8240, 40)	df=1 T=0.0 (5% 3.8)	9399	9030	369	9215
Echline Fields	E	SUERC-42920 (8230, 29)		9398	9029	369	9214
Low Hauxley	E	SUERC-49879 (8207, 32)		9282	9026	256	9154
Milltimber	E	SUERC-68095 (8142, 30) SUERC-73594 (8176, 31)	df=1 T=0.6 (5% 3.8)	9261	9011	250	9136
Fiskary Bay	W	Beta-251113 (8070, 50) Beta-234855 (8200, 50)	df-1 T=3.4 (5% 3.8)	9263	8996	267	9130
Echline Fields	E	SUERC-42917 (8107, 29) SUERC-40216 (8115, 30)	df=1 T=0.0 (5% 3.8)	9126	8991	135	9059
Nether Park	E	SUERC-84117 (8101, 29)		9125	8989	136	9057
Criet Dhu	W	SUERC-58144 (8062, 30) SUERC-58153 (8133, 29)	df=1 T=2.9 (5% 3.8)	9117	8991	126	9054
Staosnaig	W	AA-21627 (8110, 60)		9275	8778	497	9027
Fordhouse Angus	E	OxA-8225 (8100, 45)		9265	8781	484	9023
Kinloch	W	GU-2146 (8080, 50)		9257	8771	486	9014
Auchareoch	W	OxA-1601 (8060, 90)		9266	8640	626	8953
Daer Reservoir 1	W	AA-30355 (8055, 75)		9254	8642	612	8948
Lussa Wood 1	W	SRR-159 (7963, 200) SRR-160 (8194, 350)	df=1 T=0.3 (5% 3.8)	9410	8460	950	8935

Milltimber	E	SUERC-58021 (8054, 30)		9081	8777	304	8929
Ulva Cave	W	GU-2600/1 (8040, 36)		9075	8726	349	8901
Warren Field	E	SUERC-12256 (7945, 40) SUERC-12259 (8040, 40) SUERC-12260 (8040, 40) SUERC-12262 (8080, 35) SUERC-12257 (8100, 40)	df=4 T=9.1 (5% 9.5)	9017	8780	237	8899
Ben Lawers	E	OxA-8967 (8045, 55)		9121	8650	471	8886
Standingstones	E	SUERC-68124 (7960 29) SUERC-68126 (7967 30) SUERC-57938 (7985 25) SUERC-68125 (7988 29) SUERC-49726 (8026 38)	df=4 T=2.2 (5% 9.5)	8993	8725	268	8859
Northton	W	AA-50336 (7925, 55) AA-50335 (7980, 50)	df=1 T-0.5 (5% 3.8)	8988	8687	301	8838
Aisla View	W	SUERC-2394 (7900, 55) SUERC-2400 (8015, 55) SUERC-2393 (8045, 55)	df=2 T=3.9 (5% 6.0)	8998	8652	346	8825
Rubha Port an t-Seilich	W	SUERC-83792 (7943, 25) SUERC-83791 (8008, 25)	df=1 T=3.4 (5% 3.8)	8991	8659	332	8825
Camas Daraich	W	OxA-9783 (7985, 50)		9001	8646	355	8824
Redkik Point	W	UB-2470 (7935, 110) UB-2455 (8000, 65)	df=1 T=0.3 (5% 3.8)	9001	8645	356	8823
Milltimber	E	SUERC-54051 (7963, 27)		8989	8649	340	8819
Links House	E	SUERC-28284 (7875, 40) SUERC-28285 (7895, 50) SUERC-28280 (7905, 40) SUERC-28275 (7935, 40) SUERC-28274 (7965, 40) SUERC-28282 (7975, 40) SUERC-28281 (7990, 40) SUERC-28279 (8000, 40) SUERC-28289 (8010, 40) SUERC-28283 (8015, 40)	df=9 T=13.6 (5% 16.9)	8986	8651	335	8819
Chest of Dee	E	SUERC-65005 (7904, 35) SUERC-65012 (7912, 35) SUERC-58526 (7930, 28) SUERC-65017 (7941, 35) SUERC-65013 (7945, 35) SUERC-65011 (7958, 27) SUERC-65016 (7961, 35) SUERC-65015 (7974, 35) SUERC-58527 (7990, 28)	df=8 T=6.2 (5% 15.5)	8983	8646	337	8815
Criet Dhu	W	SUERC-58146 (7894, 29) SUERC-58155 (7900, 29) Beta-288420 (7900, 40) SUERC-58154 (7910, 29) SUERC-58139 (7941, 29) SUERC-58136 (7951, 30) SUERC-58149 (7960, 30) SUERC-58157 (7988, 30)	df=7 T=9.0 (5% 14.1)	8979	8639	340	8809
Staosnaig	W	AA-21624 (7935, 55)		8988	8605	383	8797
Kinloch	W	GU-2039 (7925, 65)		8986	8601	385	8794
Broom Lodge	E	SUERC-15879 (7905, 40)		8981	8596	385	8789

Fordhouse Angus	E	OxA-10057 (7890, 50) OxA-10058 (7920, 50)	df=1 T=0.2 (5% 3.8)	8980	8596	384	8788
Longhowe	E	SUERC-15587 (7900, 35)		8980	8595	385	8788
West Voe	E	OxA-14147 (7881, 38)		8978	8553	425	8766
Chest of Dee	E	SUERC-65014 (7879, 35) SUERC-65006 (7885, 35)	df=1 T=0.0 (5% 63.8)	8928	8592	336	8760
Kinloch	W	GU-2145 (7850, 50) GU-2147 (7880, 70)	df=1 T=0.1 (5% 3.8)	8974	8543	431	8759
Castlelandhill	E	SUERC-39750 (7860, 35)		8928	8546	382	8737
Druimvargie	W	OxA-4609 (7890, 80) OxA-1948 (7810, 90)	df=1 T=0.4 (5% 3.8)	8983	8480	503	8732
Auchareoch	W	OxA-1600 (7870, 90)	df=1 T=2.2 (5% 3.8)	8992	8462	530	8727
Inverness Castle Street	E	GU-1377 (7800, 85)		8980	8408	572	8694
Newton	W	GU-1954 (7805, 90) GU-1953 (7765, 225)	df=1 T=0.0 (5% 3.8)	8980	8408	572	8694
Nethermills	E	SUERC-93093 (7868, 31) SUERC-93097 (7887, 31)	df=1 T=0.2 (5% 3.8)	8772	8593	179	8683
Standingstones	E	SUERC-57937 (7825, 30)		8716	8538	178	8627
Criet Dhu	W	SUERC-58158 (7741, 29) SUERC-58165 (7795, 30) SUERC-58135 (7795, 29) SUERC-58164 (7797, 29) SUERC-58138 (7824, 29) SUERC-58163 (7830, 30) SUERC-58156 (7844, 29) SUERC-58159 (7852, 29) SUERC-58147 (7852, 30) SUERC-58134 (7858, 29) Beta-221402 (7830, 80) SUERC-58145 (7879, 29)	df=11 T=18.2 (5% 19.7)	8639	8585	54	8612
Rubha Port an t-Seilich	W	Beta-363964 (7790, 40) Beta-288423 (7820, 40)	df=1 T=0.3 (5% 3.8)	8642	8479	163	8561
Staosnaig	W	AA-21619 (7760, 55) AA-21621 (7780, 55) AA-21625 (7780, 55) Q-3278 (7720, 110)	df=3 t=0.3 (5% 7.8)	8600	8447	153	8524
Fiskay Bay	W	Beta-251109 (7730, 60) Beta-251112 (7760, 50)	df=1 T=0.1 (5% 3.8)	8594	8427	167	8511
Sand	W	OxA-9281 (7715, 55) OxA-12096 (7744, 37) OxA-9343 (7765, 50)	df=2 T=0.5 (5% 6.0)	8591	8430	161	8511
Tarradale	E	SUERC-46141 (7729, 29)		8589	8423	166	8506
Chest of Dee	E	SUERC-65007 (7705, 35)		8587	8411	176	8499
Links House	E	SUERC-28290 (7695, 40)		8587	8403	184	8495
Nether Park	E	SUERC-84114 (663, 24)		8536	8394	142	8465
Staosnaig	W	AA-21622 (7660, 55) AA-21623 (7665, 55)	df=1 T=0.0 (5% 3.8)	8540	8388	152	8464
Rubha Port an t-Seilich	W	Beta-363963 (7640, 30) Beta-288428 (7660, 40) Beta-363965 (7690, 40)	df=2 T=1.0 (5% 6.0)	8520	8389	131	8455
Loch A Squirr	W	OxA-9305 (7620, 75)		8590	8216	374	8403

Camas Daraich	W	OxA-9782 (7670, 55) OxA-9784 (7545, 55) OxA-9971 (7575, 75)	df=2 T=2.7 (5% 6.0)	8451	8347	104	8399
Sand	W	OxA-9280 (7520, 50) OxA-9282 (7545, 50) OxA-16487 (7666, 45)	df=2 T=5.6 (5% 36.0)	8419	8350	69	8385
An Corran	W	OxA-13551 (7485, 55) OxA-14753 (7525, 45) OxA-14751 (7555, 45) OxA-14752 (7595, 50) OxA-4994 (7590, 90)	df=4 T=2.7 (5% 9.5)	8408	8331	77	8370
Kinloch	W	GU-2149 (7570, 50)		8513	8206	307	8360
Coulererach	W	OxA-4924 (7530, 80)		8519	8175	344	8347
Rubha Port an t-Seilich	W	Beta-288424 (7540, 40)		8415	8207	208	8311
Fallago Rig	E	SUERC-54190 (7480, 30)		8371	8195	176	8283
Fiskary Bay	W	Beta-251114 (7460, 50) Beta-251111 (7470, 50)	df=1 T=0.0 (5% 3.8)	8364	8190	174	8277
Staosnaig	W	AA-26227 (7420, 65) AA-21626 (7480, 55)	df=1 T=0.5 (5% 3.8)	8365	8185	180	8275
Temple	W	SUERC-33736 (7470, 30) SUERC-33737 (7440, 30) SUERC-34911 (7460, 40) SUERC-34912 (7400, 40)	df=3 T=2.1 (5% 7.8)	8336	8192	144	8264
Northton	W	AA-50333 (7395, 45) AA-50334 (7420, 45) AA-50332 (7525, 80)	df=2 T=2.0 (5% 6.0)	8336	8180	156	8258
Raschoille Cave	W	OxA-8398 (7480, 75)		8417	8047	370	8232
North Carn	W	SRR-161 (7414, 80)		8372	8035	337	8204
Lon Mor	W	AA-8793 (7385, 60)		8339	8035	304	8187
Bolsay	W	Q-3219 (7250, 145) AA-21632 (7400, 55)	df=1 T=0.9 (5% 3.8)	8332	8035	297	8184
Auchareoch	W	OxA-1599 (7300, 90)		8329	7961	368	8145
Fallago Rig	E	SUERC-54191 (7306, 30)		8176	8030	146	8103
Caochanan Ruadha	E	SUERC-58040 (7252, 30) SUERC-58041 (7259, 30)	df=1 T=0.0 (5% 3.8)	8170	8010	160	8090
Raschoille Cave	W	OxA-8439 (7250, 55) OxA-8535 (7265, 80)	df=1 T=0.0 (5% 3.8)	8174	7977	197	8076
Loch A Squirr	W	OxA-9255 (7245, 55)		8177	7965	212	8071
Chest of Dee	E	SUERC-58520 (7225, 28)		8168	7964	204	8066
Lesmurdie Road	E	Poz-5488 (7190, 50) Poz-5489 (7260, 50)	df=1 T=1.0 (5% 3.8)	8170	7961	209	8066
Tarradale	E	SUERC-46140 (7202, 29)		8159	7939	220	8049
Caochanan Ruadha	E	SUERC-67810 (7150, 30) SUERC-67814 (7210, 30)	df=1 T=2.0 (5% 3.8)	8023	7945	78	7984
Chest of Dee	E	SUERC-59012 (7134, 29)		8014	7873	141	7944
Gleann Mor	W	Beta-32228 (7100, 125)		8172	7686	486	7929
Rubha Port an t-Seilich	W	Beta-288425 (7010, 50) SUERC-83786 (7048, 25)	df=1 T=0.5 (5% 3.8)	7937	7795	142	7866
Staosnaig	W	AA-21620 (7040, 55)		7971	7735	236	7853

Rubha Port an t-Seilich	W	SUERC-83788 (6902, 25)		7791	7672	119	7732
Milltimber	E	SUERC-58189 (6843, 31)		7747	7604	143	7676
Bolsay	W	AA-21633 (6810, 55)		7778	7571	207	7675
Rockside	W	Beta-37624 (6800, 40)		7692	7575	117	7634
Tulloch Wood	E	GU-3091 (6740, 70) GU-3096 (6740, 70)	df=1 T=0.0 (5% 3.8)	7679	7510	169	7595
Chapelfield Stirling	E	AA-26226 (6705, 60) GU-7201 (6710, 70)	df=1 T=0.0 (5% 3.8)	7667	7486	181	7577
MacArthur Cave	W	OxA-1949 (6700, 80		7675	7430	245	7553
Garthdee Road	E	SUERC-8614 (6690, 35) SUERC-8615 (6620, 35)	df=1 T=2.0 (5% 3.8)	7580	7474	106	7527
Warren Field	E	SUERC-12258 (6635, 35) SUERC-12251 (6740, 70)	df= 1T=1.8 (5% 3.8)	7583	7433	150	7508
Cowie Road	E	AA-20413 (6530, 75)		7571	7285	286	7428
Sand	W	OxA-16488 (6497, 44)		7505	7315	190	7410
Chest of Dee	E	SUERC-74122 (6492, 28)		7465	7324	141	7395
Morton B	E	Q-989 (6450, 110)		7570	7162	408	7366
Sand	W	OxA-16489 (6343, 43)		7417	7164	253	7291
Smittons	W	OxA-1595 (6260, 80)		7414	6951	463	7183
Milltimber	E	SUERC-68113 (6251, 30)		7259	7021	238	7140
Chest of Dee	E	SUERC-58525 (6216, 28) SUERC-58524 (6236, 29) SUERC-50742 (6249, 28)	df=2 T=0.7 (5% 6.0)	7250	7020	230	7135
Low Hauxley	E	SUERC-49869 (6209, 32)		7248	6996	252	7122
Castlelandhill	E	SUERC-39751 (6200, 35)		7245	6990	255	7118
Star 1, Loch Doon	W	OxA-1596 (6230, 80)		7319	6906	413	7113
An Corran	W	AA-29316 (6215, 60)		7258	6959	299	7109
Chest of Dee	E	SUERC-74121 (6140, 28) SUERC-50741 (6169, 29)	df=1 T=0.5 (5% 3.8)	7159	6962	197	7061
Morton B	E	Q-988 (6147, 125) Q-928 (6115, 155)	df=1 T=0.0 (0.5% 3.8)	7257	6785	472	7021
Caisteal nan Gillean I	W	Q-3009 (6035, 70) Q-3007 (6120, 80) Q-3008 (6190, 80)	df=2 T=2.2 (5% 6.0)	7159	6855	304	7007
Biggar Common	W	GU-2988 (6080, 60) GU-2987 (6300, 130)	df=1 T=2.4 (5% 3.8)	7162	6805	357	6984
Carriden	E	OxA-7852 (6030, 55)		7153	6735	418	6944
Aisla View	W	SUERC-3603 (5985, 40)		6943	6683	260	6813
Milltimber	E	SUERC-68115 (5962, 29)		6887	6679	208	6783
Arden Arboretum	E	GU-19161 (5930, 40)		6881	6663	218	6772
Risga	W	OxA-3737 (5875, 65) OxA-2023 (6000, 90)	df=1 T=1.3 (5% 3.8)	6892	6631	261	6762
Castlelandhill	E	SUERC-39748 (5915, 35)		6845	6660	185	6753
Broom Lodge	E	SUERC-15880 (5905, 40)		6846	6640	206	6743
Meiklewood	E	OxA-1159 (5920, 80)		6950	6504	446	6727
Chapelfield Stirling	E	GU-7207 (5890, 90)		6941	6492	449	6717

Kilpatrick	W	GU-1561 (5870, 75)		6884	6493	391	6689
Priory Midden	W	Q-3001 (5870, 50)		6836	6506	330	6671
Shewalton	W	OxA-1947 (5840, 80)		6850	6445	405	6648
Priory Midden	W	Q-3000 (5825, 50)		6744	6495	249	6620
Morton B	E	OxA-4612 (5790, 80)		6782	6403	379	6593
Spurryhillock	E	Beta-73552 (5860, 70) Beta-73553 (5700, 70)	df=1 T=2.6 (5% 3.8)	6728	6447	281	6588
Milltimber	E	SUERC-68110 (5737, 30) SUERC-68116 (5780, 30)	df=1 T=1 (5% 3.8)	6637	6490	147	6564
Priory Midden	W	Q-3002 (5717, 50)		6642	6399	243	6521
Nether Park	E	SUERC-84108 (5701, 23)		6557	6406	151	6482
Castlelandhill	E	SUERC-39752 (5690, 35) SUERC-39753 (5660, 35)	df=1 T=0.4 (5% 3.8)	6503	6396	107	6450
Inverness Muirtown	E	GU-1473 (5635, 65)		6599	6295	304	6447
Fordhouse Angus	E	OxA-8226 (5660, 40)		6552	6315	237	6434
Ulva Cave	W	GU-2602/3 (6011, 36)		6681	6154	527	6418
Cnoc Coig	W	Q-1352 (5430, 130) Q-1351 (5495, 75) Q-1354 (5535, 140) Q-3005 (5650, 60) Q-1353 (5645, 80) Q-3006 (5675, 60) OxA-8004 (5740, 65)	df=6 T=9.5 (5% 12.6)	6489	6315	174	6402
Nether Park	E	SUERC-84110 (5633, 23)		6486	6317	169	6402
Chapelfield Stirling	E	OxA-9750 (5590, 55)		6486	6292	194	6389
Priory Midden	W	Q-3004 (5470, 50) Q-3003 (5510, 50)	df=1 T=0.3 (5% 3.8)	6393	6367	26	6380
Skilmafilly	E	Poz-7703 (5500, 40) Poz-7700 (5510, 40) Poz-7702 (5600, 40)	df=2 T=3.8 (5% 6.0)	6395	6290	105	6343
Storakaig	W	Beta-307787 (5540, 40)		6404	6280	124	6342
Inveresk	E	AA-49321 (5510, 40)		6396	6213	183	6305
Caisteal nan Gillean I	W	Q-3011 (5450, 50) Q-3010 (5485, 50)	df=1 T=0.2 (5% 3.8)	6387	6196	191	6292
Cleaven Dyke	E	GU-3911 (5500, 120) GU-3912 (5550, 130)	df=1 T=1.6 (5% 3.8)	6528	6011	517	6270
Cnoc Sligeach	W	BM-670 (5426, 159)		6622	5895	727	6259
Cnoc Coig	W	OxA-8014 (5495, 55) OxA-8019 (5615, 45)	df=1 T=2.8 (5% 3.8)	6200	6293	-93	6247
Braehead Alloa	E	GU-4835 (5880, 60)		6436	6014	422	6225
Smittons	W	OxA-1594 (5470, 80)		6437	6004	433	6221
Morton B	E	OxA-4611 (5475, 60)		6401	6029	372	6215
Inveravon	E	GX-2331 (6010, 180) GX-2334 (5955, 180)	df=1 T=0.5 (5% 3.8)	6531	5892	639	6212

Caisteal nan Gillean II	W	Birm-346 (5150, 380 Q-1355 (5460, 65) Birm-347 (5450, 140)	df=2 T=0.6 (5% 6.0)	6394	6012	382	6203
Staosnaig	W	AA-21629 (5415, 60)		6307	6003	304	6155
Blackdog	E	SUERC-68123 (5373, 29)		6280	6007	273	6144
Daer Reservoir	W	AA-43004 (5355, 45)		6279	6000	279	6140
Summerston	W	AA-28390 (5345, 55)		6280	5995	285	6138
Ulva Cave	W	OxA-3738 (5750, 70)		6422	5836	586	6129
Inveresk	E	AA-49323 (5305, 40) AA-49322 (5340, 45)	df=1 T=0.3 (5% 3.8)	6258	5997	261	6128
Garvald Burn	E	AA-51538 (5370, 75)		6297	5947	350	6122
Skilmafilly	E	Poz-7699 (5260, 40) Poz-7698 (5300, 40) Poz-7701 (5380, 40)	df=2 T=4.7 (5% 6.0)	6190	5999	191	6095
Port Lob	W	SUERC-15043 (5705, 35) SUERC-21085 (5720, 40)	df=1 T=0.1 (5% 3.8)	6342	5828	514	6085
Storakaig	W	Beta-307788 (5250, 40) Beta-264734 (5350, 50)	df=1 t=2.4 (5% 3.8)	6188	5943	245	6066
West Voe	E	GU-11218 (5730, 60)		6257	5869	388	6063
Milltimber	E	SUERC-73592 (5280, 31)		6185	5940	245	6063
Rubha Port an t-Seilich	W	SUERC-83787 (5278, 25)		6182	5942	240	6062
Nether Park	E	SUERC-84109 (5263, 22)		6178	5936	242	6057
Biggar Common	W	GU-2985 (5250, 50)		6185	5916	269	6051
Mumrills	E	GU-3284 (5569, 70) GU-3285 (5790, 70)	df=1 T=5.0 (5% 3.8)	6242	5850	392	6046
Newbridge	E	AA-53693 (5235, 55)		6186	5906	280	6046
Caisteal nan Gillean II	W	Birm-348 (5666, 95)		6355	5701	654	6028
Caisteal nan Gillean II	W	OxA-8005 (5480, 55)		6181	5780	401	5981
An Corran	W	AA-29315 (5190, 55)		6178	5755	423	5967
Morton B	E	OxA-4610 (5180, 70)		6180	5747	433	5964
Port Lob	W	SUERC-16343 (5555, 35) SUERC-16341 (5620, 35)	df=1 T=1.7 (5% 3.8)	6217	5678	539	5948
Warden's Dyke	W	GU-3511 (5120, 100)		6177	5604	573	5891
Warren Field	E	SUERC-12261 (5170, 35)		5999	5762	237	5881
Storakaig	W	Beta-288429 (5120, 40) Beta-288431 (5130, 40)	df=1 T=0.0 (5% 3.8)	5935	5752	183	5844
Blackdog	E	SUERC-58599 (5111, 28)		5926	5751	175	5839
Chest of Dee	E	SUERC-50743 (5047, 26) SUERC-50744 (5074, 27) SUERC-28264 (5074, 28)	df=2 T=0.7 (5% 6.0)	5900	5764	136	5832
Aisla View	W	SUERC-3602 (5090, 35)		5915	5745	170	5830
Links House	E	SUERC-24028 (5065, 35) SUERC-24023 (5080, 35) SUERC-24027 (5110, 35)	df=2 T=0.6 (5% 6.0)	5908	5749	159	5829
Storakaig	W	Beta-288430 (4970, 40) Beta-307790 (5060, 40) Beta-307789 (5100, 40)	df=2 T=5.5 (5% 36.0)	5899	5724	175	5812