THE LAND OF ALWAYS WINTER

An Examination into the Impact of the AD536 Climatic Downturn in Early Medieval Scotland

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DECLARATION

I declare that this dissertation has been composed by myself and that the work of which it is a record was performed by myself. The dissertation has not been admitted in any previous application for a degree at this or any other university. All sources of information have been specifically acknowledged.

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ABSTRACT

Archaeological research has long examined the relationship between humans and their environment, and with the threat of modern climate change, this field of research is increasingly prominent. The AD536 dust-veil event, a severe fourteen-year global climatic downturn triggered by a cluster of large volcanic eruptions, may have had considerable impacts on 1st millennium peoples, particularly in the agrarian societies of northern Europe. Whilst the recent identification of this downturn has transformed understandings of the 'Migration Era Crisis' long recognised in the archaeological record of Scandinavia, no rigorous archaeological research has thus far considered the impact of this event in Britain and Ireland. This study seeks to address this lacuna, focusing on the modern geographical area of Scotland, where the early medieval period has long suffered from a lack of excavated material and chronological resolution. Through a review of the current archaeological literature, and the calibration and analysis of a dataset of newly attained radiocarbon dates from Pictland, several key trends and changes have been identified, including changes in land-use, material culture, burial practices, and settlement patterns, which are indicative of a major disruption to the ongoing social processes of the mid-6th century AD. Perhaps most significantly, it appears that discontinuity may exist in the enclosed settlements of Pictland before and after c.AD600, aligning with wider processes culminating in the rise of kingdoms and increasingly centralised systems of power. The coincidence of major change, not only in Scotland but also in neighbouring Scandinavia and Ireland, makes a compelling case for the AD536 event being a key factor in these processes. While further research will be required, this work provides a unique and important opportunity to better understand the factors determining past resilience and vulnerability. Culture and environment can no longer be seen as isolated, and with the looming threat of modern climate change and increasingly severe and frequent volcanic eruptions, research in this field may prove essential; both to our understanding of the past, and to our response to present challenges.

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1. INTRODUCTION

Archaeology has a long tradition of examining the relationship between past human societies and their environment, including the impact of climatic changes on human cultures. This field of research has not always been widely accepted, with many scholars rejecting simplistic and deterministic explanations of cultural change which fail to give appropriate agency to past peoples. However, in recent decades, and with the increasing threat of modern, human driven, climate change, archaeologists are more frequently seeking to understand complex human environment interactions, as well as the relationship between past climatic and cultural changes. When conducted appropriately, this research can allow us to not only better understand past societies and drivers of cultural change, but also their resilience to such drivers; understanding of which may prove crucial in our fight against modern climate change.

Recent research on the AD536 ‘dust-veil’ event, a severe climatic downturn, is part of the emerging focus in archaeological research on the human-climate dynamic. This event, caused by a cluster of large volcanic eruptions, was witnessed by multiple writers in the Mediterranean region, who describe a veiling of the sun which lasted up to 18-months, as well as unusual and cold weather (Arjava 2006). However, far from a short-lived ‘event’, tree-ring records from around the world demonstrate a distinct and severe drop of up to $4^{o}C$ in summer temperatures, lasting c.fourteen years, with the climate not completely ameliorating for up to a century (Newfield 2018). Whilst this is unlikely to have had extreme impacts on societies in more forgiving southerly regions, on the agricultural fringe of Europe the colder and shorter summers that characterised the downturn may have had severe consequences for agriculture and subsistence (Newfield 2018). In Scandinavia, the mid-6th century has long been recognised as a period of significant change and disruption, with evidence for abandonment of land, population decline, and social transformation, known as the ‘Migration Era Crisis’. Recent work has convincingly demonstrated that the climatic downturn was likely a key agent in triggering these transformations, with the ‘dust-veil’ and wintery summer conditions even leaving their mark in the Ragnarök myth (Gräslund & Price 2012). However, despite this ground-breaking research, which has transformed our understanding of complex mid-1st millennium changes in Scandinavia, little rigorous archaeological work has been undertaken in comparable regions of Europe, such as Scotland and Ireland.

This study seeks to redress this lacuna by assessing the potential impact of the AD536 climatic downturn in early medieval Scotland. There are several reasons for the lack of discourse on this subject thus far, key among them being the lack of focused archaeological investigation into early medieval Scotland, resulting in a dearth of securely dated sites. This has resulted in a lack of clarity in the archaeology, and specifically the chronology, of this period, an issue recognised by Wainwright in the seminal conference 'The Problem of the Picts' (Wainwright 1955). The lack of research and secure chronology has likely also obscured changes that could be related to the AD536 event, leading to its almost complete absence in the literature. Thankfully, over recent decades research has begun to fill this gap, with work such as the University of Aberdeen's Northern Picts and Comparative Kingship projects beginning to produce archaeological material and dates which are redefining our understanding of this complex and transformative period.

Crucially, whilst the AD536 climatic downturn was relatively severe, and has been demonstrated to have had considerable impact in comparable regions such as Scandinavia, this does not mean that it necessarily had a similarly extreme impact in Scotland, and it need not have been a 'disaster' nor a 'crisis'. The recent archaeological focus on the impact of climatic changes on past human societies has taken a more nuanced approach than earlier, more deterministic, literature and has highlighted the diversity of cultural responses to environmental changes. Whilst climatic changes have the potential to have significant impacts on past peoples, this impact is determined by social and cultural factors which underlie the resilience of societies. Past peoples were not necessarily vulnerable nor weak in the face of climatic changes, and often display resilience and adaptability to even extreme fluctuations. Thus, archaeological research which examines the impact of such events on past human cultures can allow us to better understand this diversity, which is key to better understanding both the societies themselves, and the human-environment relationship.

As such, this study is not attempting to find, identify, or create a previously unknown crisis in the archaeological material of early medieval Scotland, but rather to understand the interplay between this climatic downturn and the complex societies, processes, and transformations of this period. Two methods have been utilised to this end. Firstly, in Chapter 4, the archaeological literature addressing the mid-1st millennium in Scotland has been reviewed, to identify the key trends and changes of this period, which have, as yet, never been considered in relation to the AD536 event. Recent work has increasingly identified the 5th to 7th centuries

AD as a key period of change in Scotland, however, only in very few cases has the AD536 downturn been mentioned as a possible factor in these changes. Of course, correlation does not guarantee causation, and these changes are likely the result of a complex combination of social and cultural drivers, however, to better understand these drivers we must consider this climatic downturn. The second method employed is the analysis of a dataset of radiocarbon dates collected by the University of Aberdeen as part of a recent programme of excavation. Whilst the trend review section of this research focuses on all regions of Scotland, these dates come primarily from Pictland, with further analysis undertaken on the dates from the primary site type, enclosed settlements.

Several key and significant transformations in the mid-1st millennium AD have been identified here, not only in literature but also in the analysis of newly attained dates, which suggest discontinuity in site use between the 6th and 7th centuries AD. Comparison between the trends observed in Scotland, and those in Scandinavia and Ireland, suggests that in all three of these regions, the mid-6th century AD represented a turning point, and the climatic downturn should be considered as a significant factor in all of these regions. However, the diversity in the changes triggered in these regions highlights the cultural aspect of how past peoples were impacted by environmental changes, and indeed, we cannot consider these factors as isolated. Whilst this research is only the very beginning of what is needed to understand the impact of the AD536 event, it is clear that better understanding this event may be integral to our understanding of not only the complex transformations of early medieval Scotland, but also of resilience and vulnerability more generally. With both modern climate change and the threat of large tropical eruptions, such as that behind the AD536 event, looming, this is important not only for archaeological research, but also our progress into the future.

2. LITERATURE REVIEW

Whilst the impact of the AD536 event on early medieval Scotland has never been studied, there remains a substantial body of relevant literature which highlights the striking absence of this topic from the discourse. This chapter will begin by reviewing the theoretical background, including the history of research into climatic events and cultural change, as well as the concepts of resilience, adaptation and diversity in how human cultures respond, cope, and sometimes collapse in response to environmental hazards. Next, the research history of the AD536 event itself will be summarised, examining its origins, cause and climatic effects, as well as the previous archaeological research into its impacts on human societies. Finally, the archaeology of early medieval Scotland will be summarised, laying the groundwork for the trends which are reviewed in Chapter 4. It is clear that the absence of this topic from the discourse in Scotland is potentially hindering not only our understanding of the impact of the AD536 event, and climatic downturns more broadly, but also our understanding of this complex, dynamic and critical period of early Scottish history.

2.1 ENVIRONMENT, CLIMATE AND HUMAN CULTURES

The close and dynamic relationship between humans and their environment has long been recognised in archaeological research. The rise of the discipline of environmental archaeology from the mid-20th century has been integral to the formation of better understandings of how humans and their environment are highly intwined (Murphey & Fuller 2017). However, beyond understanding and characterising the contemporary environment of archaeological sites, there is also a long history within the archaeological field of assessing the impact that changing climate and environment, and natural disasters, had on past human cultures. This, however, has been a somewhat contentious research avenue.

Processual archaeology placed considerable emphasis on the role of the environment in the human past, viewing all cultural evolution as the cultural adaptation to environmental change (Van de Noort 2011). This highly environmentally deterministic view of human development, and one which persists amongst some scholars and in popular media, often embraces catastrophism, and is highly criticised by those who view it as assuming that pre-modern societies were weak and vulnerable (Newfield 2018). The subsequent theoretical movement, post-processual archaeology, emphasised human agency as the principal means by which societal and cultural change was achieved, rejecting simplistic and monocausal climate-based explanations for change, and rendering climates role effectively invisible (Van de Noort 2011; Britton & Hillerdal 2019; Hudson 2012).

However, in recent decades there has been a rejection of this dismissal of environmental impacts. Primarily, this view relied on a, now largely rejected, view of humans and the environment as separate and distinct, with a strict divide between nature and culture (Hudson *et al*. 2012.) This is a very modern, and western, view, which does not apply to many contemporary indigenous groups, and likely did not apply in the past (Mitchell 2008). Additionally, alongside the recognition that culture and nature are not so easily separated, the threat of modern climate change has brought the study of how humans coped with past environmental and climatic change once more to the fore. With human-driven climate change arguably the most significant threat we are facing in modern times (IPCC 2022), researchers from wide ranging disciplines, including archaeology, are examining how their research can contribute to the solution. Archaeology is uniquely placed to assist in this challenge, as our long history of studying human and environment interactions over long timescales, and the extensive record that archaeologists collate, not just for past environments and climates, but also for how human cultures were impacted by these changes, provides a wealth of information and data which may inform modern modelling and solutions (Mitchell 2008; Hudson *et al.* 2012; Jones & Britton 2019; Murphy & Fuller 2017; Sandweiss & Kelley 2012; Van de Noort 2011; Britton & Hillerdal 2019).

Far from the narrowly deterministic stance which post-processualists rejected, recent research on the role of climate in the past has taken a more nuanced and refined approach. Key here is the understanding that nature and culture are not separate, but highly intertwined, and, as such, the impact that climatic changes, and natural hazards, will have on a society is determined by not only environmental, but also cultural and societal factors. As such, climatic and environmental changes had diverse impacts, with a range of factors, such as subsistence practices, land-use, technological, social, economic, and political structures, determining the differential resilience of past societies (Van de Noort 2011; Torrence & Gratton 2002). The impact and responses vary not only in nature but also in temporality and duration, and must not be assumed to be negative, as 'positive' responses are possible. Models such as resilience theory, born out of ecology, have proved integral to studying this complex and holistic socio-ecological dynamic (Hudson *et al*. 2012; Bradtmoller *et al*. 2017). Additionally, resilience, and conversely, vulnerability, are not always evenly distributed geographically or socially, and understanding this complexity is an additional challenge (Torrence & Gratton 2002).

As such, the emerging view of the relationship between environmental and cultural change does not deny human agency, whilst still acknowledging the role that the environment can have in stimulating and triggering change, whether it be collapse and catastrophe, or rather adaptation, transformation, resilience or stability. Additionally, cultural change is not always driven by environmental factors, and many additional non-environmental drivers exist (Hudson *et al.* 2012; Torrence & Gratton 2002). Understanding these factors and determining whether a causal link exists between climatic and cultural change remains a challenging task, with both the archaeological and paleoenvironmental records having limitations which can make establishing both correlation and causation difficult. However, despite the challenging aspects of this topic, the role of the environment in the past can no longer be discounted, and rigorous archaeological studies are beginning to untangle these complex relationships (Costanza *et al.* 2006; Torrence & Gratton 2002). Recent research on the impact of the AD536 downturn, is part of the current research trend into past climate change, and better understanding its impact across a broader range of societies will be key to our understanding of both this event, and the societies that were impacted by it.

2.2 THE AD536 CLIMATIC DOWNTURN

First identified over four decades ago, the AD536 'dust-veil' event, and accompanying climatic downturn, did not enter archaeological discourse for a further two decades. Over the last forty years, our understanding of this event has increased considerably, however there remain disparate explanations and opinions over its cause, chronology, geology, and impact (Newfield 2018). Much of this research has been contentious, with determinist and catastrophic viewpoints perhaps causing many scholars to be wary of the topic altogether. However, in the last decade considerable progress has been made in understanding both the mechanics and impact of this downturn, and what was once understood as an 'event', with a duration of perhaps eighteen months, is now known to have been a downturn lasting c. fourteen years.

The AD536 event's earliest mention was in a footnote in Hammer *et al.* (1980), added in proof, which identified a strong acidity signal in the South Greenland ice-core, preliminarily dated to AD540±10, with a similar horizon later being identified in the Greenlandic Dye-3 ice-core (Herron 1982), suggestive of a significant volcanic eruption. This was followed up by Stothers and Rampino (1983) and Stothers (1984) who identified and examined four Mediterranean historical sources describing observations of the AD536 dust-veil. This was the first time the eyewitness reports of the bizarre veiling of the sun had been collated, however as these findings were published in a geophysical journal, it took a decade to attract significant attention within classical studies. From these descriptions, Stothers and Rampino (1983) suggested that observations of a ‘dry fog’ could represent the most explosive eruption in recorded history, with Stothers (1984) suggesting that this event exceeded the climatic consequences of any other volcanic cloud observed during the last three millennia.

Alongside the ice-core registers and historical accounts, the final piece of the puzzle which cemented the AD536 event as real and significant, were tree-ring reconstructions, published in 1991, which showed narrowing of growth rings from AD536, with the narrowest ring event in AD540±1, extending the duration of the ‘event’ from eighteen months to a multi-year downturn (Baillie 1991). However, whilst the climatic impact of the AD536 downturn was beginning to become evident, there remained some doubt over its cause.

2.2.1 Cause

Whilst the initial explanation for the AD536 dust-veil and downturn, was one or multiple large volcanic eruptions, the redating of the above ice-cores cast this into doubt for several decades, leading researchers to explore other potential causes for this event, including extra-terrestrial impacts (Baillie 1994; 1995; 1999; 2007). However, the publication of new ice-cores (Larson *et al.* 2008) and subsequent redating of these proxies (Baillie 2008; 2010), identified a major cluster of volcanic eruptions as the primary driver of this downturn. Whilst the specific volcanoes that erupted are still unknown, it is undisputed that an initial large northern eruption in AD535/6 caused the dust-veil observed in the Mediterranean, with a secondary, larger eruption closer to the equator in AD540/1, causing global cooling. The largest two downturn eruptions were comparable to the strongest eruptions of the last 1200 years, and smaller, but still large, eruptions occurred around AD545/6 and 550/1, further exacerbating the climatic impacts (Sigl *et al.* 2015). Whilst a volcanic cause is now largely undisputed some evidence remains for an additional impact event, and this complexity of cause goes somewhat towards explaining its unusual impact, duration, and regional variability (Abbott *et al*. 2008; Newfield 2018).

A full explanation of the history of investigation into the cause of the AD536 event is located in **Appendix 1,** as this has considerably influenced the archaeological research history of this subject. However, whilst the exact causes of the climatic downturn remain open to refinement, as archaeologists it is arguable this is largely irrelevant to our study of their impact on past societies, just as the cause would have been likely unknowable to those who lived through these events (Gräslund & Price 2012). Indeed, far more relevant to our understanding of the human experience of these events are the environmental proxies which allow us to assess their climatic impact.

2.2.2 Climatic Impact

One of the most reliable proxies for past climatic conditions are tree-growth-rings which can be assessed in dendroclimatological studies. Crucially, whilst tree-growth-rings from mid-latitude, low elevation regions, such as the Mediterranean region, provide insight into precipitation, records from higher altitude and latitude areas rather reflect summer temperatures (Newfield 2018). Whilst winter precipitation may be crucial to agriculture in some regions, in northern latitudes such as Scandinavia, and indeed Scotland, which are located on the fringe of agricultural viability, colder summers and shortened growing seasons could be detrimental to agrarian societies (Gräslund & Price 2012). As such, the information provided by tree-ring studies is integral to understanding the impact of climatic events in areas of the agricultural north.

Toohey *et al*. (2016) estimated that the extra tropical radiative forcing from the volcanic double event was larger than that of any period of the last 1200 years, and climatic reconstructions show declines of between 1.5-5^{o}C (Newfield 2018; Büntgen *et al*. 2016). Whilst in lower latitude regions, reconstructions suggest that there was a drastic decrease in precipitation, aligning with historical accounts of drought, tree-ring material from northern Europe suggest this period was one of extreme lows, particularly in AD536, 540-1, and 545-6 (Baillie 1991; 1994), with AD536 as the second coldest summer in the last 1500 years (Briffa *et al*. 1990; Baillie 1995). Of the sixteen coldest summers in the northern hemisphere since 500BC, six occurred between AD536 and 550 (Sigl *et al*. 2015). Additionally, a recent study has suggested the initial c.fourteen-year downturn may have been the impetus of a much longer period of cooling due to ocean and sea-ice feedback, as well as an exceptional solar minimum, causing a 115 year 'Late Antique Little Ice Age' (Büntgen *et al*. 2016).

Thus, beyond representing a cluster of distant volcanic eruptions, and an eighteen-month dust-veil of currently unknown geographical extent, the AD536 'event' caused almost unprecedented and unrepeated cooling and climatic decline, the impact of which would have been particularly felt in already marginal agricultural areas such as Scandinavia and Northern

Britain. Other climatic proxies such as speleothems, ice-cores, glaciers, and frost rings in subfossil pinewood, have corroborated the dendroclimatological evidence, clearly demonstrating the extreme climatic impact of the volcanic eruptions (Helema *et al.* 2018; Luterbacher *et al*. 2012; Holzhauser *et al.* 2005; Kobashi *et al.* 2011). This impact must have been felt by contemporary human societies, and indeed, there is increasing evidence of these complex human-climate interactions.

2.2.3 Historical Sources

Five contemporary and independent eye-witness accounts from the Mediterranean have been identified which describe the immediate impacts of the AD536 event (Stothers & Rampino 1983; Stothers 1984; Arjava 2006). It is beyond the scope of this chapter to fully explore each source (see Arjava 2006), however these accounts variously describe a darkening, or veiling, of the sun, lasting for up to eighteen-months, and the failure of harvests, famine, pestilence, and war.

Whilst the Mediterranean sources are currently the only that mention the ‘veiling’, there are other, more widely spread sources, which reflect the impact of this event and its climatic effects. From China, there are reports of drought, early frost, and snow in AD536 as well as unusual summertime cold, frost and snow in AD537 (Houston 2000; Weisburd 1985). From Japan there are reports of cold and hunger from AD536 and from Korea winter blossoming and snowfall in spring (Newfield 2018). The Irish Annals mention failures of bread in AD536 and 538/9, and the Welsh *Annales Cambriae* report of mortality in Britian and Ireland in AD537, though how many of these events can be directly related to the downturn remains open to debate (Baillie 1999).

It is striking that the veiling of the sun, clearly considered noteworthy by the Mediterranean observers and which has given the ‘dust-veil’ label to this event, is absent from all other accounts, despite tree-ring records demonstrating that the climatic impact was widespread. Based on the historical accounts available it seems likely that the fog described in the Mediterranean was only visible at latitudes north of 35^{o}, aligning with patterns observed in stratospheric aerosol veils from large eruptions of northern volcanoes (Arjava 2006). Whilst this suggests that this dust-veil was present in northerly regions, including those for which we do not have historical accounts such as Scandinavia and Scotland (its presence in Scandinavia is argued by Gräslund & Price 2012), there is no way to be certain of this, and its distribution, density and duration likely varied.

Whilst the historical accounts available corroborate the volcanic eruptions and resulting climatic downturn of the mid-6th century, they alone provide little insight into the wider impact and complex consequences of this downturn. These accounts are often vague, brief, and incomplete, and are removed from regions which may have been most vulnerable to its effects, such as the northern agricultural fringe, where archaeological evidence is crucial to our understanding of this event.

2.2.4 And then a Volcano Erupted – A problematic history

Before summarising the archaeological research on the AD536 event, it is necessary to address its more problematic research history, which has perhaps contributed to the reluctance of many archaeologists to discuss it as a causal factor. Alongside David Key's (1999) book, *Catastrophe,* which has attracted criticism for its wide-reaching and unnuanced claims (Dark 1999), a documentary broadcast on Channel 4 in the UK and PBS in the US titled *Catastrophe! How the World Changed*, further brought the topic into popular media. Countless news articles have discussed the year AD536 and the 'catastrophe' that occurred, often quoting historian Michael McCormick who labelled AD536 as the 'worst year to be alive' (Gibbons 2018). The portrayal in popular media often lacks nuance and the instant label of 'catastrophe' feeds into the 'and then it was destroyed by a volcano', school of history (Pomeroy 2008; Gräslund & Price 2012). Many scholars justifiably see this as unjust to past peoples and cultures, many of whom were resilient to climatic fluctuations, however whilst this dramatization is undoubtedly unhelpful, it should not stop a critical and nuanced investigation into its potential impacts and effects. When undertaken correctly and allowing for such events **not** to have been catastrophic, research into climatic events can be invaluable, and these subjects must be tackled in order to overcome these overly simplistic misconceptions.

2.2.5 Archaeological Research

The AD536 event only entered archaeological discourse at the beginning of this millennium. As well as hesitance surrounding determinism and portrayals in popular media, the realities of archaeological dating and the difficulty in directly associating changes seen in material culture with relatively short-lived climatic events, has hindered archaeological research on this topic. The AD536 event is now well understood as a fourteen-year climatic downturn, rather than an eighteen-month dust-veil, however, as radiocarbon dates have a tendency to 'smear' things through time (Tvauri 2014), this is an extremely specific time period to be able to identify in the archaeological record, raising valid concerns of confirmation-bias when identifying changes related to this event (Widgren 2012).

However, whilst it may be difficult to directly relate changes in the archaeological record to this climatic downturn, and it is important to be cautious in any attempt to do so, it is counterproductive to discount such a significant climatic shift as a factor altogether. Sudden drops in summer temperatures of several degrees, and shortened growing seasons, likely had disastrous consequences for food production. In recent decades archaeologists have been successful in making convincing arguments for the identification of the impacts of the AD536 event, with research in Scandinavia leading the way.

2.2.5.1 Scandinavia & The Baltic

Well before the identification of a climatic downturn in the mid-6th century, there was a well-known 'crisis' observable in the archaeological record from this period in Scandinavia, known as the Migration Era Crisis, which also marked the shift from Early to Late Iron Age societies. The cause of this 'crisis' which was characterised by declining settlement numbers, depopulation (up to 50%), abandonment of pastures and reforestation, was unknown, with suggestions ranging from war to plague. However, Axboe (1999 & 2001) in analysing the considerable increase in the deposition of gold hoards in this period, was the first to link the Migration Era Crisis to the AD536 event. At this time Axboe was largely alone in this theory, however following the publication of a paper by Gräslund in 2008, and the building of this argument with the publication of a paper alongside Price in 2012 (Gräslund & Price 2012) this idea began to be examined more widely in the discourse. Gräslund & Price (2012) related the AD536 event not only to the Migration Era crisis seen in the settlement patterns and gold hoards, but also the shift from a 'sun worship' belief to belief centred around the Norse Gods, arguing that the Fimbulwinter described in the Ragnarök myth was created from a memory of the real climatic crisis of the mid-6th century. Other authors have also discussed the potential impact of this event on Norse mythology (Nordvig & Reide 2018; Holmberg *et al*. 2020)

Several studies have demonstrated the significant shifts in settlement and burial patterns in the mid-6th century. Löwenborg (2012) examined the distribution of burial grounds in Vastermanland, east central Sweden and the Malaren Valley, finding a lack of continuity between the use of burial grounds from the Early Iron Age and the Late Iron Age. Further evidence for a considerable crisis in the mid-6th century lay in a drastic decline in pollen of cereals and vegetation indicative of human activity, and large-scale abandonment of land, such as in eastern-central Sweden where villages, previously located on low-lying land, were abandoned, with new settlements founded on higher ground (Löwenborg 2012; Gräslund & Price 2012). The sheer scale of this crisis, as well as the patterns of land abandonment and population decline, such as the abandonment of low-lying ground, align well with the AD536 downturn being a causal factor. Additionally, Bondenson and Bondenson (2014) suggested that the extreme, cold, and damp conditions of the downturn may have resulted in an outbreak of epidemic ergotism, a highly toxic fungus that spreads through crops and pastures with toxic effects on both humans and animals. Ergotism not only causes illness and death but also supresses fertility, causing marked demographic effects, corresponding with the patterns observed in the palaeoenvironmental and archaeological records. This demonstrates the complex processes underlying the impacts of climatic downturns.

However, beyond the impacts observable in the archaeological record, archaeologists have argued for a longer-lasting impact of the AD536 event. Löwenborg (2012) and Gräslund and Price (2012), argued that the largescale abandonment of land following the AD536 crisis increased private ownership of land, as an elite few were able to acquire large landholdings, resulting in an increasingly stratified social order and the rise of an aristocratic class. From the mid-6th century onwards, increased concentration of power is evident in Scandinavia, as well as the formation of a strikingly different political economy, with an increased focus on the elite ownership of land. This new power structure is manifested in new types of monumentalised cemeteries and settlements, in new locations, and there is an increase in defendable sites as well as the emergence of powerful elite manors (Löwenborg 2012; Gräslund and Price 2012). Indeed, Gräslund and Price (2012) argue that the AD536 event and the changes in wrought were the catalysts for the long social trajectories that ultimately resulted in the Viking diaspora. However, scholars have also noted that these processes were not so simple, with many of the changes observable in the archaeological record having started prior to AD536 and being part of wider shifts occurring throughout Europe following the fall of the Roman Empire, raising the question of whether the climatic downturn instigated or aggravated these processes (Widgren 2012).

However, not all regions of Scandinavia and the Baltic were impacted in the same way, or to the same level, by the downturn. Archaeological and palynological data suggest that Estonia also saw massive depopulation of up to 70%, and complete abandonment of land, with northern Estonia remaining largely unoccupied until the 9th century (Tvauri 2014). However, in

Finland where hunting and fishing were the main livelihood, with agriculture being of marginal importance, a similar catastrophe does not appear in the archaeological record. Rather, it appears that the disruption of Finland's trade networks as its neighbours went into crisis, had an important role in forming new unique material culture and instigated increased land cultivation within Finland itself (Tvauri 2014). Similar patterns are seen in northern Norway and northern Sweden which previously relied more heavily on wild resources (Tvauri 2014; Wallin 2004). This demonstrates the complexity of the impact of such climatic changes, and in this case the societies more reliant on agricultural land were those most impacted, whilst those with a wider resource base appear more resilient. This highlights the importance of detailed, and regional, archaeological research into the impacts of such events.

2.2.5.2 Other Regions

There has been little archaeological research into the AD536 event outside of Scandinavia, however it has been discussed by scholars from broader disciplines. As discussed above, the climatic impacts of the AD536 event varied considerably by region, and in some more southerly areas, drought appears to have been the primary consequence. In Mayan Central America, it has been suggested that the AD536 event was the impetus for the sharp break between the Early and Late Classical Periods (Newfield 2018; Gill 2000). Baillie (1991) suggested that there was a major increase in sites in North America following the AD536-45 event, and in the Rhone Valley and Northern Gaul arable land was laid to pasture and reforested due to an extended period of wet and cold (Cheyette 2008).

In other disciplines, and outside of academia, some authors have attributed extensive change to this event. One of the most popular proponents of this is David Keys, in his book which treated the AD536 event as a watershed moment between the ancient and modern world, linking it to events as wide-reaching as the rise of Islam and the destabilisation of the Byzantine empire, not only through the Justinian Plague but the incursions of barbarians. Whilst many are critical of his wider claims, the linking of the AD536 event to the Justinian Plague is perhaps valid and undoubtedly a necessary discussion. The Justinian Plague emerged in the Byzantine Empire around AD541 and had reached Ireland by AD544 (Newfield 2018). Thus, separating the impacts of the AD536 event and the Justinian Plague, and the potential depopulation caused by both, poses a significant challenge. However, it has been suggested that these events were not distinct, as the AD536 event created ideal conditions for the pathogen to thrive, reduced human immunity, and instigated mass migrations which introduced the plague into the Mediterranean region (Baillie 1995; Newfield 2018; Helema *et al.* 2018). Thus, the effects of the climatic downturn and the Justinian plague are not mutually exclusive, but rather highly related, and must be considered together.

Whilst many are critical of the far-reaching impacts Keys (2001) assigned the AD536 event, other scholars have also linked the downturn to the considerable changes seen in the mid-first millennium. Büntgen (*et al*. 2016) discusses how the 6th century coincides with the rising and falling of civilisations, pandemics, human migration, and political turmoil, linking the AD536 event (and what they call the Late Antique Little Ice Age) to increased conflicts in Mongolia and northern China, upheavals in central Asia, the westward movement of steppe people, the transformation of the eastern Roman Empire, collapse of the Sasanian Empire and the rise of the Islamic Empire. However, this research is very much in an infant stage, largely failing to consider the complex interactions between this climatic downturn and the other social and cultural processes underlying these changes.

2.2.5.3 Britain and Ireland

We will now examine the research conducted closer to the region under examination here. Baillie has most extensively researched the potential impact of the AD536 downturn in the Britain and Ireland. His 1999 book, *Exodus to Arthur* explored both historical accounts, as well as folklore, tales and mythologies thought to have origins in the 6th century such as the legends of Arthur (also discussed by Keys 2001; Breeze 2016). However, this analysis was strongly focused on Baillie's theory at time of writing that the climatic downturn was the result of extra-terrestrial meteoric impacts, with much of his examination of the literature seeking references to such events. However, since his retraction of this theory, Baillie (2008; 2010) has not readdressed this topic.

Whilst some of both Baillie's (1995; 1999) and Keys' (2001) work addressed archaeological material and changes such as an increase in fortified sites in Ireland, the establishment of ecclesiastical sites, and the abandonment of settlements, both works were somewhat light-handed in their analysis of the archaeological material and many of their theories focused on an outdated concept of the 'dark ages'. Keys (2001) especially was criticised by early medieval specialist Ken Dark (1999) who accused Keys of mislocating and misquoting archaeological evidence and making unfounded assertions. Since these controversial works, there have been few attempts at readdressing this topic, despite the vast increase in archaeological material now available. If we turn to Scotland specifically, there has been no work thus far specifically discussing the impact of the AD536 event, and the downturn is largely absent from the archaeological discourse. More recently, it is occasionally mentioned, though often only in passing, and no rigorous studies, on the scale and quality of those undertaken in Scandinavia, have yet been produced. As such, we will now discuss the archaeological record of 1st-millennium AD Scotland.

2.3 SCOTLAND IN THE MID FIRST MILLENNIUM

The archaeology and history of the mid-1st millennium in Scotland has remained both complex and ambiguous, with the so-called 'dark ages' following the withdrawal of the Roman Empire from Britain retaining a strong element of mysticism, nowhere more so than in the areas inhabited by the elusive Pictish peoples (Carver 2011). Whilst the 5th-6th centuries AD are increasingly understood as key in the development of the later 1st millennium AD polities, both historical and archaeological evidence has typically been sparse and difficult to interpret (Gondek & Noble 2019). However, recent archaeological work is beginning to fill these gaps and our knowledge has greatly increased over the last few decades. The below sections will address the historical sources and summarise the archaeological material briefly, discussing the periodisation and divisions of Scotland in this period, outlining key background for the trends discussed in Chapter 4.

2.3.1. Between History and Prehistory

Scotland in the mid-1st millennium AD is difficult to fit into simple classificatory boxes. Not only was there no one 'people' of Scotland, but whether it is historic or prehistoric is also somewhat contentious. In different regions, and by different scholars, this phase (roughly AD300-900) is variously referred to as the Middle to Late Iron Age, the early historic period, and the early medieval period. Indeed, much of Scotland was essentially without historical sources, and the regions beyond the few that do exist, such as the West and North Atlantic zones, tend to favour an Iron Age classification (Mackie 2010). Whilst written sources are few and far between especially in the earlier phases, they are not altogether absent, and the processes occurring in Scotland align with those of broader early medieval Europe. As such, here this timeframe is referred to as the early medieval period, aligning with the general archaeological consensus.

Further complicating the picture is the designation of the modern geographical area of Scotland as a study area when discussing the early medieval period. There was no one peoples of Scotland at this time and the Scots/Gaels, with their Irish origins and connections, occupied the kingdom of Dal Riata in modern Argyll; the southwest of modern Scotland belonged to the Strathclyde Britons; the southeast was within the Anglo-Saxon kingdom of Bernica; and the Picts dominated eastern and northern Scotland (Campbell 2019; Evans 2019; Noble 2019). Whilst there are regional differences in the material culture of Scotland, these do not necessarily coincide with the known distributions of these peoples, which varied throughout this period (Campbell 2019). For the purposes of this study, which focuses on the more marginal agricultural areas of Northern Britain, we will focus on the area north of the modern Scottish border. However, just as with the peoples of early medieval Scotland, the landscapes, geography, and topography of Scotland is far from homogenous. The Lowlands, Highlands, Atlantic west and Western and Northern Isles all have diverse environments and weather patterns, likely impacting the lived experience of the AD536 downturn.

2.3.2 Historical Summary

Whilst the historical sources are sparse, there are a few records which provide some insight into the broader ongoing processes of the mid-1st millennium AD, though many of these come from neighbouring regions rather than Scotland itself (Evans 2019). The group that largely dominates Scotland in the early Middle Ages, the Picts, are first mentioned in classical sources from neighbouring Roman Britain in the late 3rd century AD, however it is unknown when or how a group emerged that considered themselves to be Pictish (Evans 2019; Fraser 2009). During the 3rd and 4th centuries there were several Roman incursions, and as with other regions on the periphery of the Roman Empire, this proximity left its mark on the archaeology and cultures of Scotland (Fraser 2009). Following the final withdrawal of Rome from Britain, the 5th-6th centuries, typically those which are key to the subject under study here, are the sparsest in the historical sources. The Pictish king lists, transcribed sometime before AD900, do contain the names of some 6th century kings, and while Pictland, and Scotland more broadly, was divided into many small kingdoms, it appears that by sometime in the 7th century, power was increasingly centralised, with the emergence of overkingships such as Fortriu in northern Pictland (Evans 2019). Whilst this key overkingship was previously thought to be located in southern Pictland, around central Scotland, Alex Woolf (2006) convincingly argued that it was instead located around Moray in northern Pictland. By the end of the 10th century all references to the Picts and Pictland cease, as Scotland is consolidated into the Gaelic kingdom of Alba, with Scandinavian regions to the north and west (Evans 2019a; Evans 2019b; Fraser 2009).

Finally, another key development in early medieval Scotland, and one which has provided us with both historical and archaeological records, was the introduction of Christianity. Whilst the conversion period remains poorly understood, texts such as Adomnán's *Life of St Columba* written c.AD697, are key sources, and suggest that missionaries were operating from at least the 6th century (Evans & Noble 2019; Foster 2019). Monasticism was established by the early 7th century, and by later in the same century, Christianity appears to have been firmly established, though the tempo and timing of this process likely varied throughout Scotland (Evans & Noble 2019).

2.3.3. Archaeological Research

The archaeology of early medieval Scotland has long been ambiguous and elusive, an issue identified in an influential conference as the 'Problem of the Picts' (Wainwright 1955). This 'problem' and one that somewhat remains, centred largely around a lack of excavation, with the dating of many sites relying purely on an assumed typological chronology. However, since 1955, there has been an exponential growth in archaeological research on both the Picts and early medieval Scotland more broadly, with aerial photography and the Royal Commission on the Ancient and Historical Monuments of Scotland (RCAHMS) surveys majorly contributing to the increase in known sites and an understanding of their distribution (Driscoll 2011; Noble 2019a; Maldonado 2013). However, it is the increase in excavated and dated sites, mostly in the last few decades, that has allowed for an understanding of chronologies and related social and cultural change.

Recent archaeological work has begun to produce dates for previously undated sites and site types. Whilst in the 1970s-80s, Leslie Alcock conducted pioneering excavations and keyhole dating on historically documented elite sites, this work was small scale, and the recent identification of Fortriu in Northern Pictland by Woolf (2006) opened the door for the University of Aberdeen's Northern Picts project, centred on the understudied regions of Aberdeenshire and Moray ((Alcock & Alcock 1990; 1992; Alcock *et al.* 1989; Noble 2019a). This project has studied not only the iconic Pictish symbol stones, creating a new chronology for this archetypal material culture (Noble *et al.* 2019c) and monumental cemeteries (Mitchell & Noble 2017), but perhaps most significantly, the main settlement type we have for the early medieval period in Scotland, enclosed settlements including lowland enclosures, ringforts, hillforts and promontory forts (Noble 2019b; Noble *et al*. 2013). Alongside earlier work in Aberdeenshire (Cook 2011; 2013) the Northern Picts and cousin Comparative Kingship project have combined larger scale excavations with dates acquired from keyhole excavations, building a chronology for the fortified settlements of Pictland (Noble 2019b). This has been complemented by large scale research elsewhere such as in the Strathearn environs and Royal Forteviot (SERF) project undertaken by the University of Glasgow (Campbell *et al*. 2019).

Alongside the enclosed settlements of early medieval Scotland, the key settlement type known from early medieval Scotland are the islet settlements of crannogs. Several recent surveys and excavations have greatly increased our knowledge of this settlement type, which spans from Neolithic through to the modern period (Crone 2012). A key development in recent years has been the incorporation of the duns of western Scotland and the island brochs of the northern isles into analysis of crannogs (Lenfert 2013; Statigos 2021). Whilst the main period of crannog building seems to have been during the Iron Age, between 400BC and AD200, many appear to have been reused or constructed in the early medieval period (Crone 2012).

Finally, belief and burial has of course been a major area of archaeological study. Whilst as yet little is known regarding pre-Christian belief in Scotland, work on sites such as Rhynie and Burghead in northern Pictland, and the analysis of Class I Pictish stones, has begun to provide some insight into these belief systems, which may have had a focus on natural places, animal sacrifice and the ancient past (Evans & Noble 2019; Noble et al. 2019b). Excavations at key early Christian sites such as Portmahamock on the Tarbet Peninsula, have added substantially to our understanding of early Christianity and monasticism in Scotland (Carver 2019), though there remains much to learn about early ecclesiastical sites (Foster 2019). Whilst the unfurnished burial of early medieval Scotland, and the appearance of cemeteries in the 5th century, before which burial was largely elusive, was at one point taken to be an indicator of the spread of Christianity, more recent work has called this into question (Winlow 2011; Maldonado 2013). Adrián Maldonado's PhD thesis (2011), and subsequent articles (2013; 2019) have been fundamental in understanding the burial practices of early medieval Scotland, which consist of simple dug graves, long cists lined with stones, log coffins, square barrows, and cairns. Burial chronologies will be discussed in Chapter Four; however, Maldonado suggested that these changes were indicative not of the arrival of Christianity or the fall of Rome, but rather part of wider fundamental shifts in the nature of personhood (Maldonado 2013: 3).

This all too brief summary has acted only to provide a framework for the more detailed trends reviewed in Chapter Four. It is worth emphasising that until recently, due to the dearth of dating, it was near impossible to identify trends and changes in the archaeological material of early medieval Scotland, which may coincide with, and indicate, social and cultural change. This perhaps somewhat explains the lack of research so far addressing the potential impact of the AD536 event, which requires relatively precise chronologies. However, with the increase in dated material, it is now possible, and indeed necessary, to begin to consider the impacts of this extreme climatic downturn.

2.4 SUMMARY

Whilst a recently identified phenomena, the AD536 event is increasingly well understood, and has been demonstrated to be a multi-phase, and almost unprecedented, climatic event. However, what is most notable from the above summary is what is absent. The historical accounts on which many authors base their arguments come from southerly regions which were likely less vulnerable than northerly, agricultural regions, such as Scandinavia, Scotland and Ireland. However, of these regions only in Scandinavia has archaeological research examined the potential impacts of this event, finding a complex picture of both rather extreme impact, and potential resilience. The extensive and convincing research from Scandinavia makes the absence of research from the Britain and Ireland striking. Whilst the considerable impact demonstrable in Scandinavia does not guarantee a significant impact in Scotland, the similarity in environmental and agricultural factors in Scandinavia and Scotland make this a valid line of inquiry. Indeed, whilst previously the material did not exist to examine the impact of the AD536 event in Scotland, with an increasing body of excavated material, assessing the impact of this downturn may now prove key to our understanding of this transformative period.

3. METHODOLOGY

Two methods were undertaken to assess the potential impact of the AD536 climatic downturn in Scotland. As this topic has rarely been discussed in relation to early medieval Scottish archaeology, the primary method employed here involved a review of the current archaeological literature. The second method was the analysis of radiocarbon dates obtained by the University of Aberdeen through the Northern Picts and the Comparative Kingship projects.

3.1 LITERATURE REVIEW

As no work has previously reviewed the impact of the AD536 climatic downturn in Scotland, it is possible that previously identified trends and changes in the archaeological material could be related to this downturn yet have gone unrecognised, potentially obscuring broader relationships. As such, a natural and necessary starting point for this study was a review of the archaeological literature and material of mid-1st millennium AD Scotland. Whilst in a few cases, researchers have mentioned the AD536 climatic downturn, this is usually only in passing, and no research has integrated these cases and themes. Thus, this review seeks to bring together references to the AD536 event, as well as the major themes and trends previously identified in archaeological research, focusing on the 5th-7th centuries AD. Whilst not all of the themes identified here may be directly related to the AD536 event, these must nevertheless be considered as they represent the broader social context at the time of the environmental downturn.

3.2 RADIOCARBON DATES

3.2.1 Dataset

The second method undertaken was the analysis of a set of radiocarbon dates obtained and collated by the University of Aberdeen's Northern Picts project, and Leverhulme funded Comparative Kingship project. The work undertaken by the University of Aberdeen since the founding of the Northern Picts project in 2012 has led to a significant dataset of dated sites from the early medieval period in Scotland, which largely suffers from a dearth of dated sites. The dates analysed here come from three main sources (**Table 1**).

Table 1: Source of dates included in dataset.

Dataset	Description	Source
1	Dates collated by the Northern Picts project as part of a review of the enclosed settlements of Northern Pictland. This dataset is a combination of dates from previous excavations on these sites, including Murray Cook's work in Strathdon (Cook 2013), and newly collected dates from excavations undertaken as part of the project.	Noble et al. (2013) Supplementary information.
2	Dates from the significant 4th-6th century AD settlement of Rhynie, excavated by the University of Aberdeen.	Noble et al. (2019b).
3	New dates obtained by the University of Aberdeen as part of the Comparative Kingship project. Included in this dataset are samples from previous excavations which have been newly submitted for radiocarbon dating, though the majority of samples were collected as part of recent excavations.	Gordon Noble (pers comm.)

Due to the focus of this work, these dates come mostly from Pictland and Eastern Scotland (**Figure 1)** and from enclosed settlements, with only a few, for example, burial dates included. Significantly, this is not a comprehensive dataset of dated sites from 1st millennium AD Scotland, acting rather as an initial, preliminary sample. A total of forty-four sites were included in the dataset. **Table 2** summarises these sites by location and site type, however a more detailed site description, history and sample detail is outlined in **Appendix 2**.

Figure 1: Distribution of sites included in dataset. Red: Enclosed Sites; Green: Burials; Blue: Other Settlement Types; Purple: Ecclesiastical Enclosures; Black: Pictish Stone. Produced by author.

Table 2: Outline of sites included in dataset. See Appendix 1 for further detail.

SITE NAME	LOCATION	SITE TYPE	Canmore ID	REFERENCES
Pool	Orkney	Pictish settlement	3422	Hunter 2007
Sandwick	Shetland	Square cairns, cellular structures, Norse farmhouses	141	Bigelow 1980; 1984; Lelong & Shearer 2004; Lelong 2006; 2007a; 2007b
Dairy Park, Golspie	Highland	Long Cist	6567	Close-Brooks 1980
Rhynie	Aberdeenshire	Enclosed lowland settlement		Gondek & Noble 2019; Noble et al. 2019a; 2019b
Kinneddar	Moray	Ecclesiastical enclosure	16459	Noble et al. 2018
Burghead	Moray	Coastal Promontory Fort	16146	Lock & Ralston 2017: SC2925; Noble 2019b; Edwards & Ralston 1978; Ralston 2004
Turin Hill	Angus	Fort complex – Large bivallette fort, smaller oval fort, three small ringforts.	34899	O'Driscoll & Noble 2020c; O'Driscoll 2018b; O'Driscoll & Noble 2020d
Ackergill	Highland	Long Cist Cemetery; Pictish Symbol Stones	9243	Hunter Blair 2004; Edwards 1926; 1927
Loch of the Clans	Highland	Crannog	36684	Stratigos 2018
Dummiefarline	Perth and Kinross	Hillfort	49618	Lock & Ralston 2017: SC3202
Rob's Reed	Angus	Ringfort	33776	O'Driscoll & Noble 2020c
Balbinny	Angus	Enclosure/Hillfort	34793	O'Driscoll & Noble 2020a
Abbey Craig	Stirling	Hillfort	47113	Cook 2019; Lock & Ralston 2017: SC1592
Gurness	Orkney	Broch	2201	Hedges 1987; Loch & Ralston 2017: SC2860
Keiss	Highland, Caithness	Broch	9182	Mackie 2007
Barmkyn of North Keig	Aberdeenshire	Ringfort	17701	Noble 2019c; Lock and Ralston 2017: SC2955)
Hill of Keir	Aberdeenshire	Ringfort	19341	Noble 2019c
Glenduckie	Fife	Hillfort	30060	Lock & Ralston 2017: SC3122; O'Driscoll & Noble 2020b
Blockie Head	Aberdeenshire	Coastal Promontory Fort	75948	Lock & Ralston: SC2987); Noble et al. 2020f
Loch Vaa	Highland	Crannog	15385	Stratigos 2020

SITE NAME	LOCATION	SITE TYPE	Canmore ID	REFERENCES
Mither Tap, Bennachie	Aberdeenshire	Hillfort	85507	Lock & Ralston 2017: SC2961; Atkinson 2007; Noble et al. 2013; Noble et al. 2020a; Mann et al. 2015
Craig Rock	Fife	Hillfort	340454	Lock & Ralston 2017: SC4229; Noble et al. 2020b
Barns Mill	Fife	Coastal Promontory Fort	-	Lock & Ralston 2017: SC3172
Migvie	Aberdeenshire	Fort	16999	Lock & Ralston 2017: SC2936
Buckquoy	Orkney Islands	Settlement	1802	Ritchie 1979; Morris & Barrowman 2021
The Gegan	East Lothian	Coastal Promontory Fort/Settlement	57866	Laidlaw 1870; Lock & Ralston 2017: SC3921; Noble et al. 2019c
Sueno's Stone	Moray	Pictish Stone	15785	McCullagh 1995; AOC 1996; Buchanan 2005
Brough Road	Orkney Islands	Burial Cairn	73552	Morris 1989; Morris & Barrowman 2021
Glamis	Angus	Vallum	365075	Noble et al. 2020e
Wag of Forse	Highland	Settlement	8608	Mackie 2007
Dumyat	Stirling	Hillfort	47117	Lock & Ralston 2017: SC1593; Cavers 2015
Cairnmore	Aberdeenshire	Ringfort	17723	Cook 2011b; Lock & Ralston 2017: SC2956; Noble et al. 2019d; Noble et al. 2020d
Saevar Howe	Orkney Islands	Settlement & Long Cist Cemetery	1835	Hedges 1983
Dunkeld	Perth & Kinross	Vallum	346595	O'Driscoll et al. 2020
Craig Dorney	Aberdeenshire	Hillfort	17275	Lock & Ralston 2017: SC2943
Aberlemno	Aberdeenshire	Settlement	34861	O'Driscoll 2018a
Norman's Law	Fife	Hillfort	31814	Lock & Ralston 2017: SC3144
Clatchard Craig	Fife	Hillfort	30074	Lock & Ralston 2017: SC3125; Close-Brooks 1986
Maiden Castle	Aberdeenshire	Ringfort	18182	Cook 2011a; Lock & Ralston 2017: SC2962
Cullykhan	Aberdeenshire	Coastal Promontory Fort	19942	Lock & Ralston 2017: SC2982
Dundurn	Perthshire	Hillfort	24873	Lock & Ralston 2017: SC2625
Urquhart Castle	Inverness-shire	Hillfort	12547	Alcock & Alcock 1992; Lock & Ralston 2017: SC2879
Craig Phadraig	Inverness-shire	Hillfort	13846	Lock & Ralston 2017: SC2896
Hill of Barra	Aberdeenshire	Hillfort	19668	Lock & Ralston 2017: SC2981; Cook 2011
Portknockie	Moray	Coastal Promontory Fort	17408	Lock & Ralston 2017: SC2945; Ralston 1987

3.2.2 Calibration and Analysis

All dates included in dataset three (**Table 1**), and many of the dates from the previous studies, were processed by the Scottish Universities Environmental Research Centre radiocarbon laboratory. This laboratory employs the standard methodologies of pre-treating, combusting, graphitising, and measuring by accelerator mass spectrometry (Dunbar et al. 2016).

All dates were calibrated in OxCal v.4.4 using Intcal20 (Reimer *et al*. 2020; Bronk Ramsay 2009), including the dates taken from previous studies as these had been previously calibrated using IntCal13 (Noble *et al*. 2013; Noble *et al*. 2019b). All dates were calibrated to 1-sigma (68.3% probability) and 2-sigma (95.4% probability) ranges. Details of the algorithms employed by OxCal are available from the online manual (https://c14.arch.ox.ac.uk/oxcal/OxCal.html) or in Bronk Ramsey (2009). Following calibration, a model was produced for all dates from the 1st millennium AD. Dates from outside this period were excluded, as were dates with wide error margins (greater than 90± years) and dates from uncertain contexts, such as those identified in Noble *et al.* (2013: supplementary material). Unfortunately, due to the nature of the dataset, in many cases the exact context of the samples were unclear, and future research should further refine these dates with a better understanding of their original context. A model was produced for enclosed settlements, as well as for other settlement types.

Finally, a probability density distribution graph for the summed ranges of the enclosed sites was produced, also in OxCal 4.4. Probability diagrams are not a reliable method of data interpretation for several reasons and the OxCal manual states that they are difficult to justify statistically (Bronk Ramsay 2022). This will be further discussed later, however this method was employed here to allow for comparison against the model produced in Noble *et al*. (2013), as referred to in Chapter 4. Nevertheless, the interpretation of this diagram will be approached cautiously.

3.3 SUMMARY

The two methods employed here are a valuable and important initial step in assessing the impact of the AD536 event in Scotland. As this is an almost entirely unstudied topic, the range of possible, and indeed necessary, lines of enquiry are substantial, and whilst only limited analyses are possible here, this research must start somewhere. Through reviewing the existing archaeological literature, and the analysis of a sample of newly collected dates, this study demonstrates the validity and potential of this topic and stands as an important steppingstone for future research.

4. RESULTS – TREND IDENTFICATION

The below section summarises the archaeological material from the mid-1st millennium AD, focusing on trends identifiable to the mid-6th and adjacent centuries. This is not to say that these trends are directly related to the AD536 climatic downturn, but rather to allow for a discussion of the context within which the AD536 event took place. Here, the few, passing, mentions of the AD536 event from the literature are collated, along with evidence for shifts in the environment, settlement and burial practices. How these changes may relate to the AD536 event will be discussed in Chapter 6.

4.1 ENVIRONMENT

4.1.1 Tree-Rings

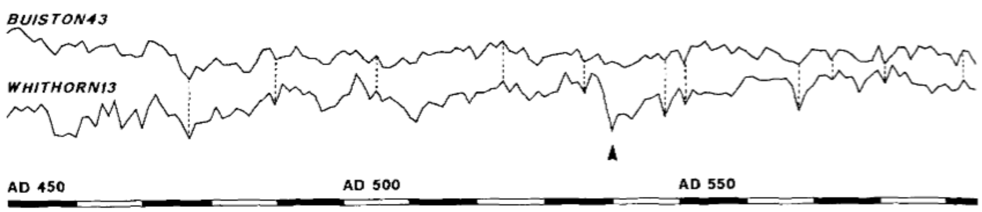

Figure 2: Sections of tree-ring chronologies from Buiston and Whithorn showing the quality of correlation between them; including the narrow growth-rings around AD540 (Crone 1998: illus 2: pg 490.)

Whilst neighbouring areas including Ireland, northern England, and Scandinavia have produced multimillennial tree-ring chronologies, almost all of which show the AD536 downturn, there have been challenges in producing similar chronologies for Scotland. Currently only two chronologies which include the 6th century AD exist (**Figure 2**), produced from the early Christian monastery of Whithorn, Dumfries and Galloway, and the crannog at Buiston, Ayrshire (Crone 1998). Both sites are in the central and southern lowlands zone, and there has been difficulty applying these to timbers from other regions of Scotland, due to vastly differing climatic conditions. The Whithorn chronology clearly shows the AD536 temperature decline, with a distinct period of restricted growth evident c.AD540, however it is noteworthy that the Buiston chronology does not (Crone 1998; Crone & Mills 2002). Due to the biogeographic diversity of Scotland, it is likely that the AD536 event affected different regions of Scotland in significantly varied ways. A study underway is attempting to build a multi-year chronology for the Cairngorms, and this, alongside potential future chronologies for other regions, will be crucial in our understanding of the regionally diverse impacts of this downturn (Wilson *et al*. 2011; Rydval *et al*. 2017).

4.1.2 Paleoenvironmental Studies

Increasingly, multi-proxy palaeoenviornmental studies are producing detailed environmental records for archaeological sites and their surrounding landscapes, and four such studies have been identified for review here. Firstly, Tipping *et al*. (2006), using pollen diagrams from two landscapes on the eastern and western coasts of northern Scotland, found evidence for late Iron Age/early medieval oak cultivation, ending suddenly around the 6th century AD. This cultivation included the creation of new woodlands in the 3rd century AD, with the introduction of oak into localities where oak had not grown for thousands of years, suggesting a long-term timber production strategy, as the maturation of the trees would have taken 150-200 years. Whilst the authors discuss that the abrupt, possibly synchrous, end to this practice in the 6th century AD may represent an intentional felling to realise the profit on the investment, they note that this seems an implausibly short-term approach to such a resource, alternatively suggesting that the venture may have become commercially unviable and/or a decision was made to repurpose the land. The authors note the broad correspondence between the end of oak growth at these sites and larger scale patterns seen in European oak populations around AD540, however, they fail to mention that these wider patterns are known to have been caused by the AD536 downturn.

Research undertaken examining the unusual and significant upland settlements and Pitcarmick-type buildings of Glen Shee, Perthshire, further establish a complex relationship between settlement activity and climate in the mid-1st millennium (Strachan et al. 2019). Whilst investigations of the site of Lair suggest this site was not founded until after the AD536 event, in the early-7th century, researchers suggest these upland settlements may have been made possible and were instigated due to climatic amelioration following the end of the ‘late antique little ice age’ as identified by Büntgen *et al*. (2016), suggesting a similar pattern of agrarian revival can be seen across Scotland.

Finally, two studies have been chosen from northeast Scotland. (Jones *et al*. 2021) examines contemporary landscape use and environment for the 4th-6th century site of Rhynie, Aberdeenshire (further discussed below); while the second (Jones *et al*. 2022) provides a similar record for the landscape surrounding Loch of Leys, Aberdeenshire, where a crannog was occupied in the 1st-3rd centuries AD, and then again from the 8th century AD. Interestingly, whilst the site of Rhynie was abandoned around cal AD510-560, landscape use appears to have continued. Contrastingly, in the landscape surrounding the crannog, arable farming seems to have picked up c.AD550-640, despite there being no contemporary archaeological evidence for settlement and a preceding period with almost no human activity in the landscape. Both sites indicated that this was a period of fluctuating wetness. It is noteworthy that neither study indicates abandonment of land or interruption to cereal cultivation, in contrast to the material from Scandinavia, although both sites are within the relatively fertile region of northeast Scotland, and further studies may indicate a diversity to landscape utilisation in this period.

4.2 SETTLEMENT & SITES

4.2.1 Enclosed Settlement

Enclosed settlements are arguably the main settlement form of mid-first millennium Scotland. Whilst, until recently there were few dates to inform chronologies of this diverse site-type, recent work has begun to establish a chronology, identifying major changes dated to the 5th-7th centuries AD (Noble *et al*. 2013; Noble 2019b; Cook 2011; 2013). All three of the major enclosed settlement types, large hilltop nuclear forts, coastal promontory forts, and ringforts/settlement enclosures, begin to be constructed in the 5th century AD, including the reuse of earlier prehistoric fortified sites. However, Noble *et al.* (2013) found that in northeast Scotland, following this pronounced period of enclosure building c. cal AD440-550, construction slows (**Figure 3**), and smaller settlement enclosures appear to go out of use, whilst the major hillfort and promontory enclosures continue to expand, before settlement at such sites stops altogether in the 9th century (Noble et al. 2013; Noble 2019b).

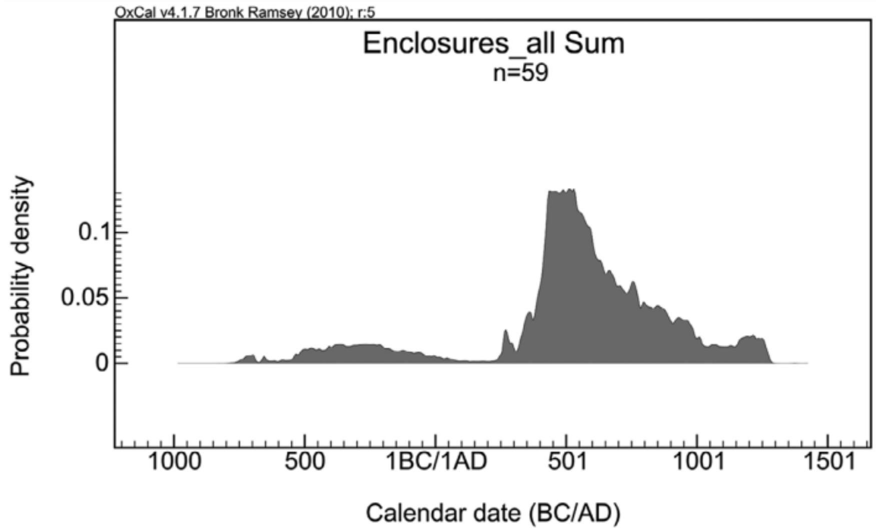

Figure 3: Probability density diagram showing all refined dates for Pictish enclosures analysed in Noble et al. (2013: Fig 7: 1146).

Rhynie, Aberdeenshire, represents a newly recognised form of lowland enclosures, which further fits into the pattern described above. Originating in the late 4th century AD, Rhynie, set within a highly symbolic landscape and yielding high-status imported goods, appears to represent an important elite centre, combining both secular and ritual power (Gondek & Noble 2019; Noble *et al*. 2019a; Noble *et al*. 2019b). Radiocarbon dates suggest Rhynie was abandoned cal AD510-560, and this is generally discussed as part of the broader patterns described above, and the rise of the overkingship of Fortriu. However, Jones *et al*. (2021) does briefly mention the climatic cooling from AD536-545, and historical documentation of crop failures, before turning to a discussion of the Justinian plague, a factor also noted by Noble *et al*. (2019b).

As such, the proliferation of enclosed sites following the Roman withdrawal from Britain likely represents localised power structures, and possibly an atmosphere that required defended settlement, with subsequent consolidation at a smaller number of sites in the early 7th century aligning with the historical evidence we have for the emergence of larger polities such as the overkingship of Fortriu (Noble *et al*. 2013; Noble 2019a). Campbell (2019) also notes that trade networks shifted in the mid-6th century AD. These patterns are often related to wider trends in the European sphere; however, the AD536 event rarely factors into these discussions.

4.2.2 Crannogs

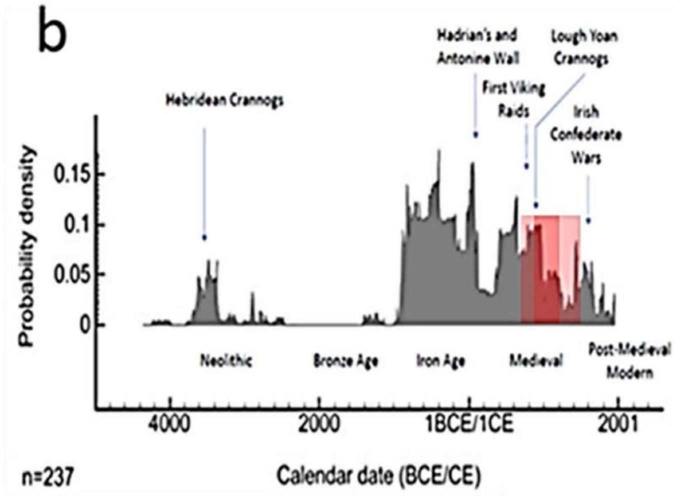

Figure 4: Crannog chronology for Britain and Ireland showing sharp uptick in crannog building between the 5th and 7th centuries AD (Brown et al. 2021: Fig 1b).

The second major settlement type from early medieval Scotland, and one which also has an origin in prehistory, are the islet sites of crannogs. Over 600 islet settlements are known from Scotland, and recent studies have collated radiocarbon dates to show distinct trends in their construction and occupation (Crone 2012). Following a major period of construction from 400BC to AD200, these sites appear to decline in the early first millennium before peaking again from 6th and 7th centuries (**Figure 4**) (Crone 2012; Brown et al. 2022). Multiple crannogs appear to have been constructed in the late 6th century, including Buiston c.AD550 (Crone 2000), and Ederline Boathouse, which has occupation limited to just a few decades in the latter 6th century (Henderson et al. 2021). Whilst dated examples are increasing, and the inclusion of the islet duns and brochs (Lenfert 2013; Stratigos 2021) is providing more accurate insight into distribution and chronologies, the recent excavations of crannog sites in northeast Scotland, producing dates from the presumed hiatus of the 8th-9th century AD, have demonstrated that a few new dates can transform chronologies (Stratigos & Noble 2014; 2017). The impetus behind crannog building is currently unknown, though factors such as religion, defence, and communal identity have been proposed (Crone 2012). Whilst the trigger for the increased construction of these sites in the early medieval period is unknown Crone (2012), discussing later prehistoric crannog proliferation, has argued that environmental stimuli should be included in explanatory models.

4.2.3 Atlantic Scotland

Mackie (2010) is one of the few scholars to discuss the AD536 event in Scotland. In his analysis of the broch cultures of Atlantic Scotland, where the mid-1st millennium is generally classified as Iron Age, he argues that the mid-6th century saw an abrupt transition to Late Iron Age Material culture, and the end of the Middle Iron Age phase which was characterised by the occupation and reuse of modified brochs. Mackie identifies several sites in the Atlantic zone which appear to have been abandoned/destroyed rather suddenly in the mid-6th century and suggests that this could be a direct result of the AD536 event.

4.3 BURIAL

Whilst the later prehistoric period represents a hiatus in our evidence for burial in Scotland, from the 5th- 6th centuries AD, cemeteries and graves begin to flourish, including long cists, dug graves, and monumental cemeteries of barrows and cairns (Maldonado 2013; Mitchell & Noble 2017). Maldonado's PhD research, which collated radiocarbon dates from 1st millennium AD burials in Scotland, has been integral in establishing a chronology for this period (2011; 2013). Maldonado found that all the grave types of the early medieval period emerged in the early centuries AD, however, were not present in large numbers until the 5th century, peaking in the 7th before being abandoned in the 8th, likely in favour of churchyards. As such, rather than being indicative of the rise of Christianity or the movement of peoples, he suggested these patterns are indicative of much more fundamental cosmological shifts in personhood and the social body (Maldonado 2013). In northeast Scotland, it has been suggested that the flourishing of monumental cemeteries in the 5th and 6th centuries AD, and the frequent association with prehistoric sites and conjoining of barrows and cairns to create linked monuments, are indicative of the use of burial practices to create lineages, perhaps tied into the emergence of hereditary aristocracy and the kingdoms evident in the fortified enclosures discussed above (Mitchell & Noble 2017).

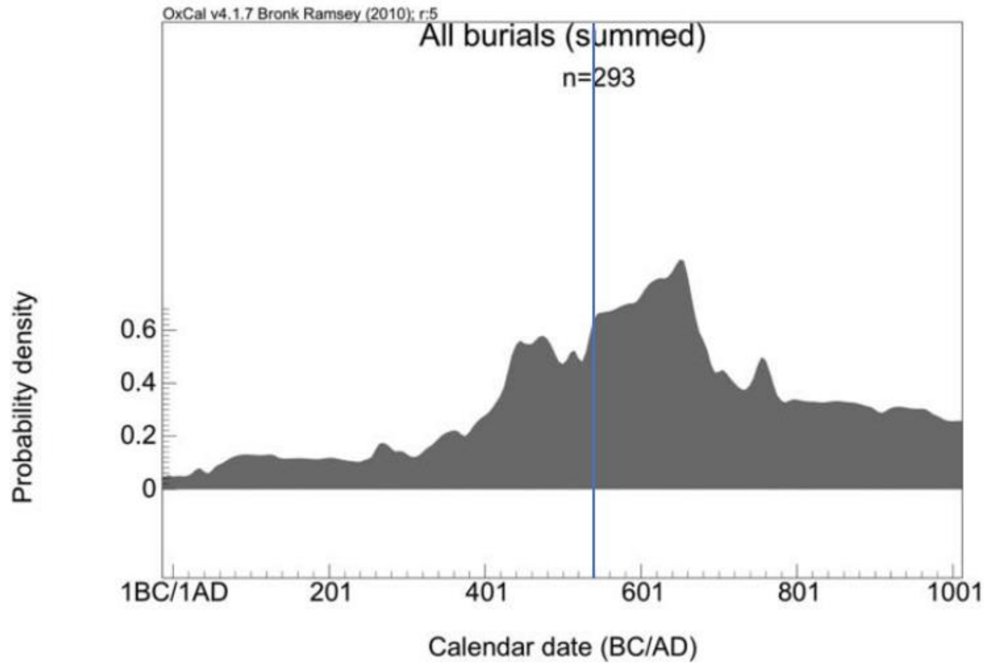

Figure 5: Sum of all radiocarbon dates from human bone from the first millennium AD in Scotland, blue line at c.540 AD added by author (Maldonado 2014: Fig 1: 4).

Figure 5 shows all burial summed, whilst **Figure 6** shows this divided by burial type (Maldonado 2013). The trends described above are evident, however in the mid-6th century itself noteworthy peaks and troughs appear (marked by the blue line in each diagram). Unfortunately, these probability diagrams are highly influenced by the shape of the calibration curve, meaning these patterns should not be overinterpreted. However, it is noteworthy that in **Figure 6**, each of the burial types display a different pattern, suggesting a process beyond the calibration curve may underlie these fluctuations, potentially indicative of a disruption to burial practices at this juncture. To better understand whether real changes occurred at this period, new methods of analysis will have to be applied, discussed in Chapter 6.

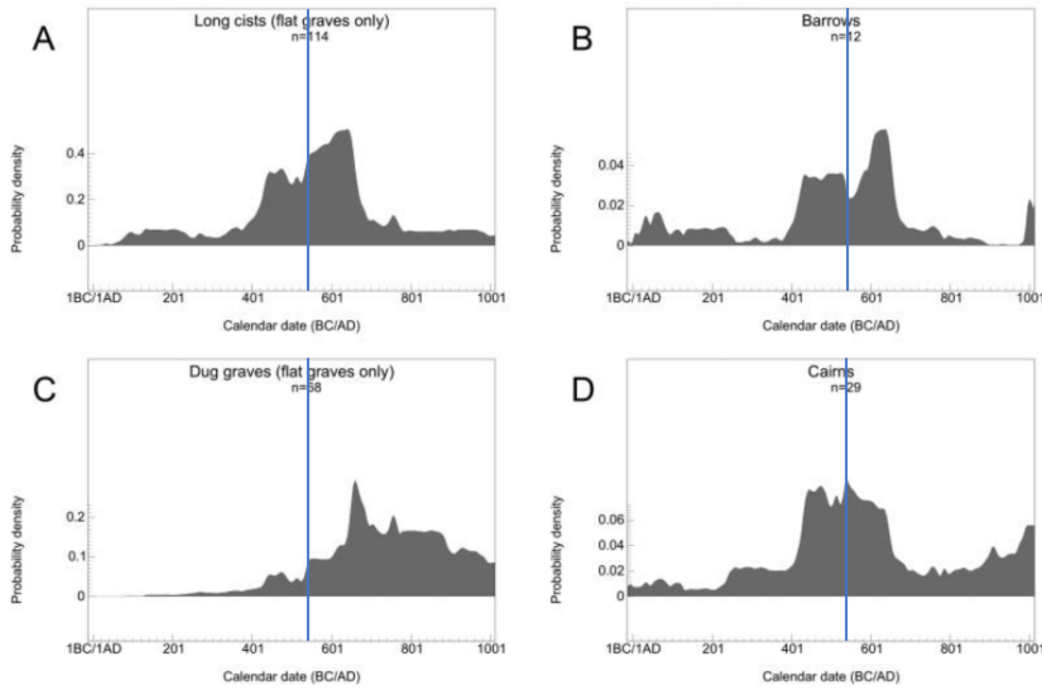

Figure 6: Sum of all radiocarbon dates from human bone by grave type, blue line at c. 540 AD added by author (Maldonado 2013: Fig 3: 5).

4.4 SUMMARY

Taken in isolation some of the above trends may seem insignificant, however, when viewed alongside each other, there is a clear pattern of change occurring in the 6th century AD, indicative of disruption to the social systems and ongoing processes of this period. It seems likely that these trends are interrelated, and whilst it is possible that the AD536 event was not the, or at least the only, catalyst for these shifts, their coincidence with the major climatic downturn means it must be considered. Noble (2019b) notes that the literary sources depict the 5th and 6th centuries as a transformative period including the emergence of more complex systems of rulership and social structure, with important changes in the archaeological record at this chronological horizon. However, this review demonstrates that alongside this broader trend, even more specific changes can be dated to approximately the mid-6th century. The question remains if/how these changes may relate to the AD536 climatic downturn, and this will be discussed in Chapter 6.

5. RESULTS – RADIOCARBON DATES

As previously discussed, the below radiocarbon dates are a combination of samples collected by the University of Aberdeen as part of the Northern Picts and Comparative Kingships projects. Crucially, this includes samples from a substantial number of newly excavated sites.

5.1 CALIBRATED RADIOCARBON DATES

Table 4, Appendix 3, includes all calibrated dates from the collated dataset, calibrated to 68.3% and 95.4% probabilities. These dates mostly belong to the 1st-millennium, outliers included in the original dataset were excluded from the following analyses.

5.1.1 Enclosed Settlements

Due to the focus of the Northern Picts and Comparative Kingships projects, and due to the nature of early medieval Scottish archaeology, a large proportion of the dataset came from enclosed sites. As this was one of the archaeological categories identified in Chapter 4 as exhibiting major changes over the 5th-7th centuries AD, this site type was the primary focus of further analysis. A model for all the enclosed sites included in the dataset is located in **Appendix 3** (**Figure 13-16).** These dates were further refined by excluding dates with a wide error margin (greater than 90± years) and, where known, samples from uncertain contexts. This refined set of dates for enclosed settlements is shown below in **Figures 7-10.** This dataset has vastly increased since Noble *et al.*'s (2013) original study, from a refined dataset of seven sites, to a refined dataset of twenty-two (excluding ecclesiastical enclosures), which is largely testament to the extensive fieldwork undertaken in recent years.

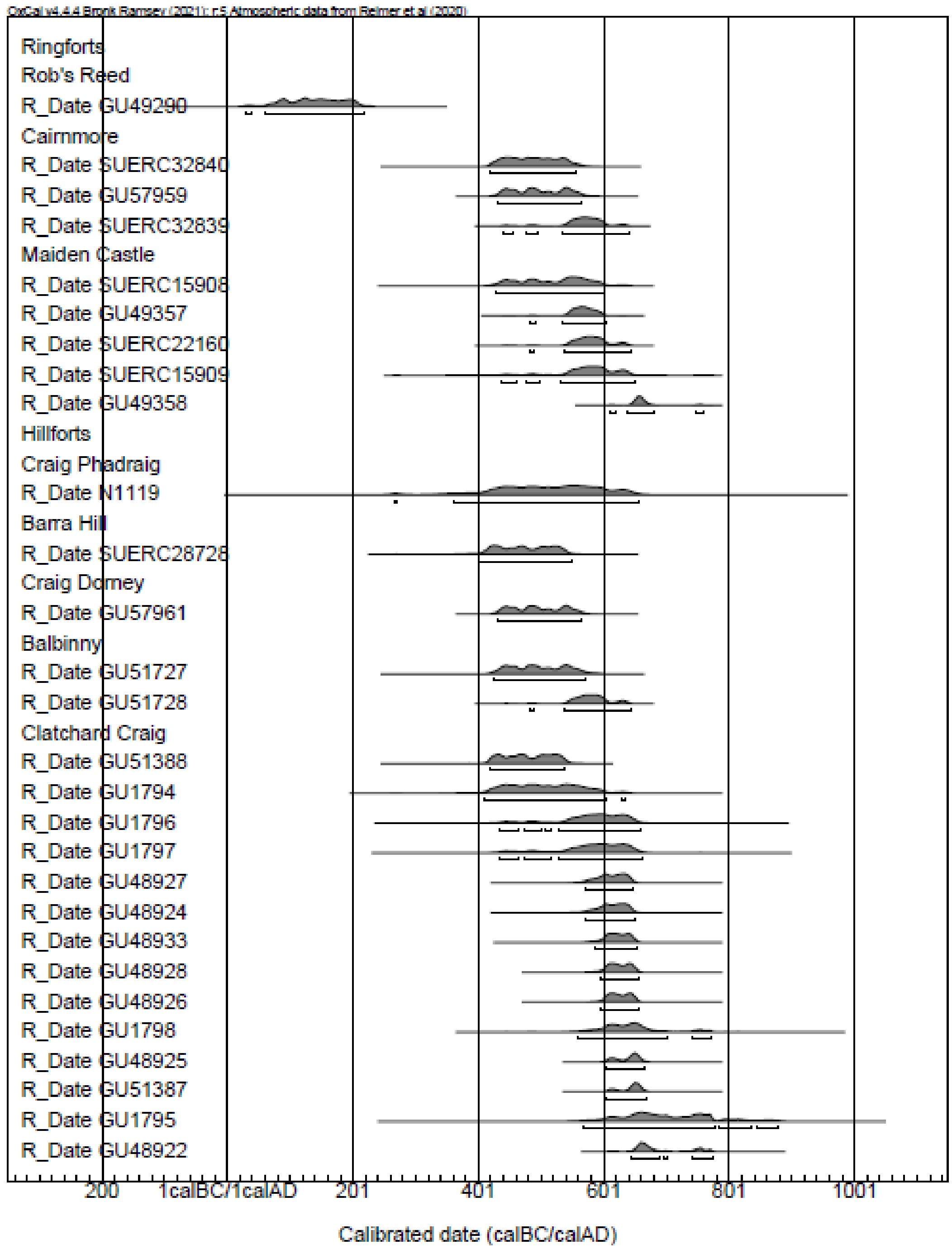

Figure 7: Refined radiocarbon dates for enclosed settlements part one; ringforts and hillforts. Produced by author in OxCal 4.4.

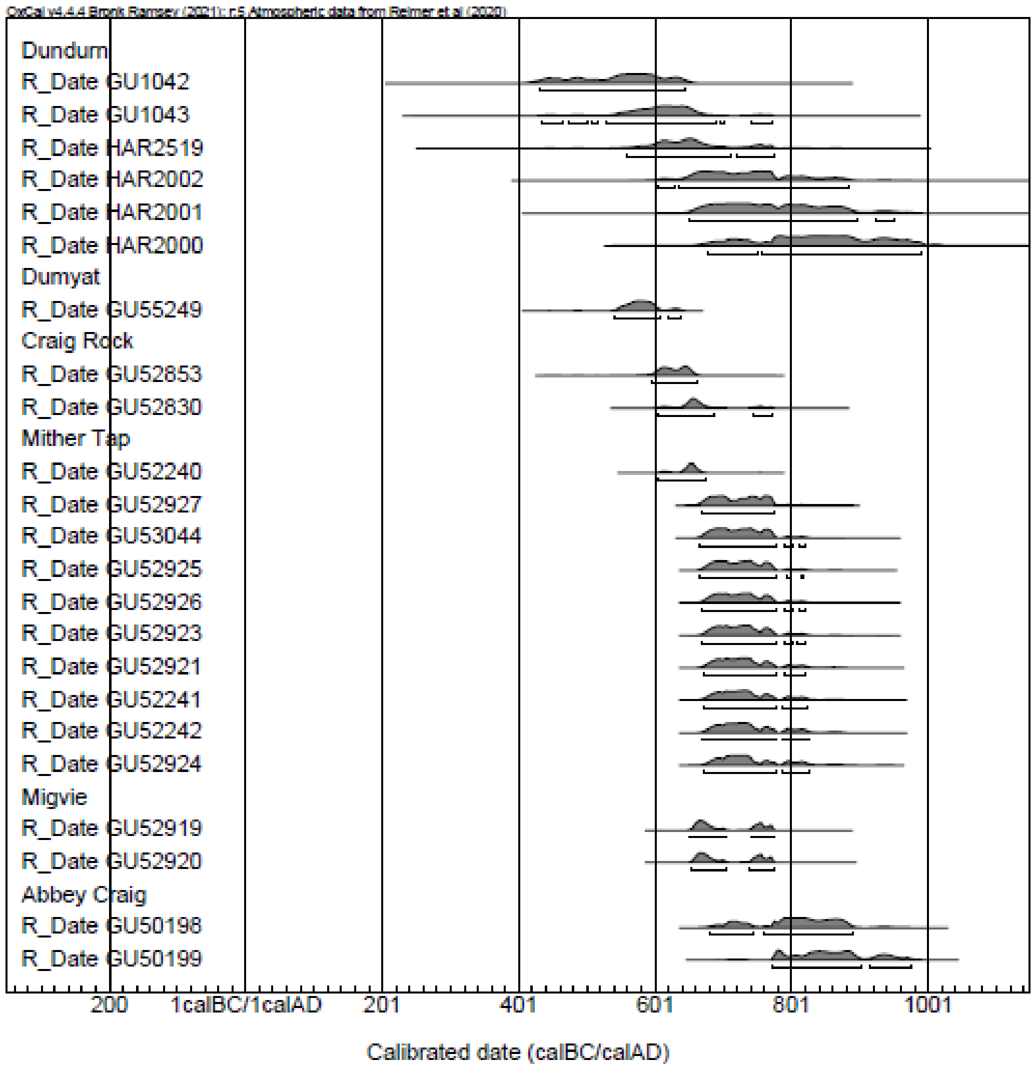

Figure 8: Refined radiocarbon dates for enclosed settlements part two; hillforts continued. Produced by author in OxCal 4.4.

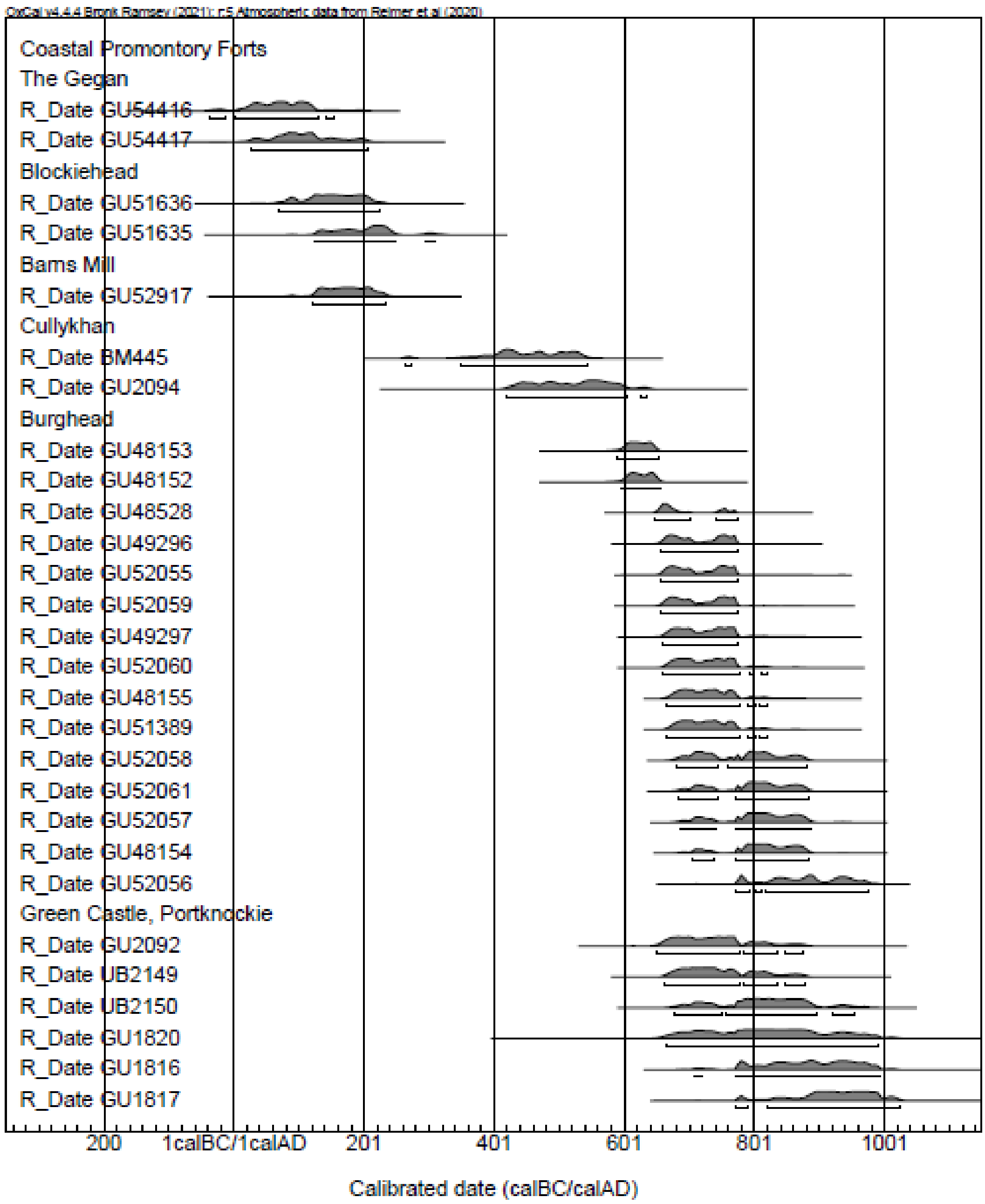

Figure 9: Refined radiocarbon dates for enclosed settlements part three; coastal promontory forts. Produced by author in OxCal 4.4

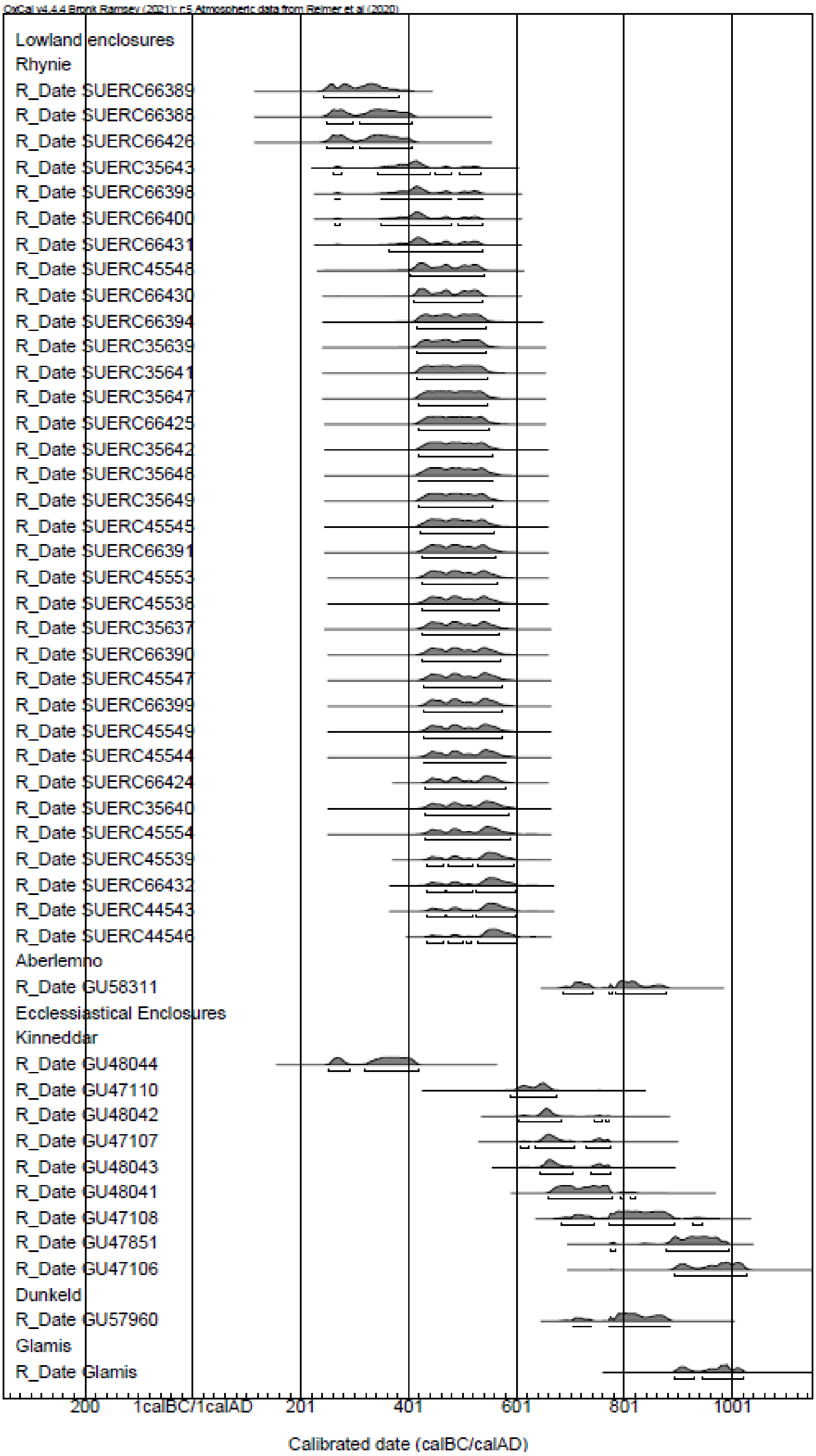

Figure 10: Refined radiocarbon dates for enclosed settlements part four; lowland enclosures and ecclesiastical enclosures. Produced by author in OxCal 4.4.

This increased dataset displays a distinct phase of fortified settlement construction beginning c.AD400, aligning with previously identified trends (Noble *et al*. 2013; Noble 2019b). Whilst the Gegan, Blockiehead, Barns Mill, and Rob's Reed returned earlier dates, these predate the early-3rd century AD and there is a distinct gap between these sites and the subsequent floruit of activity.

Utilisation of this increased dataset has indicated a possible modification to the previously identified trend. Whilst Noble *et al.* 2013 suggested that from the mid-6th century, construction declines, with smaller sites being abandoned and activity continuing at a smaller number of larger sites, it now appears that rather than a consolidation of existing sites, there is discontinuity, with new sites being established. **Table 3** outlines the sites which returned dates from the 5th and 6th centuries AD but not from the 7th century; and the sites which appear to date to a second phase of activity beginning after AD600. Notably, only two sites in the current dataset appear to span the 5th-7th centuries, however the dates from these sites have large error margins and may require revision. Additionally, in general the later sites represented in the current dataset do appear to be larger (and fewer) than the earlier ones, in line with the processes discussed by Noble *et al*. (2013).

Table 3: Distribution of sites, divided by centuries of calibrated radiocarbon dates.

Sites dating to the 6th century and earlier	**Sites spanning the 5th to 7th centuries**	**Sites dating to the 7th century and later**
Cairnmore	Dundurn	Craig Rock
Maiden Castle	Clatchard Craig	Mither Tap
Craig Phadraig		Migvie
Barra Hill		Burghead
Craig Dorney		Portknockie
Dumyat		Abbey Craig (8th century)
Balbinny		
Cullykhan		
Rhynie		

It must be acknowledged that this apparent trend is likely influenced by the nature of excavation and sample recovery, with many of the University of Aberdeen excavations targeting defence construction, meaning that actual occupation/use phases of these sites may not be represented by the current sample, potentially rendering this division arbitrary. Additionally, the above analysis and identified division is relatively crude due to the large ranges radiocarbon dates return, and further analysis is required, including Bayesian modelling. However, with so few dates from many sites, and the lack of stratigraphical information currently available, this was beyond the scope of the current study. Nonetheless, preliminary analysis suggests that beyond consolidation at a smaller number of enclosed sites from the 7th century, there was discontinuity between the sites in use before and after c.AD600. This is an intriguing hypothesis which should be tested in future research.

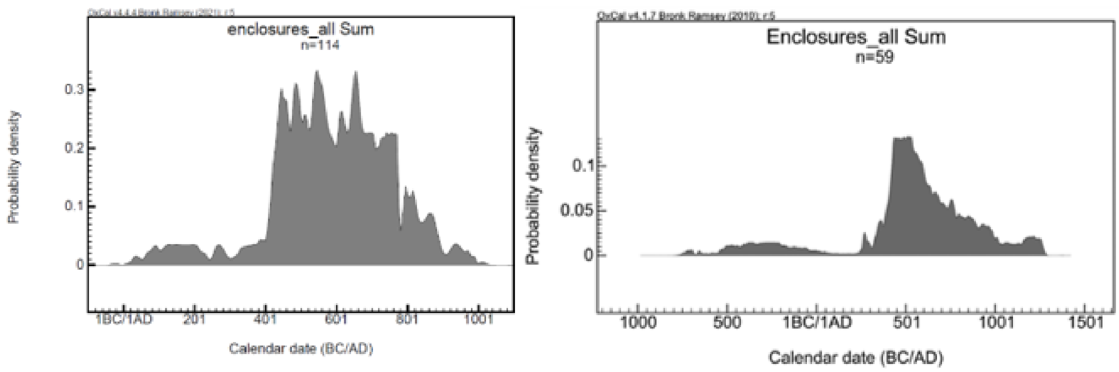

Figure 11: Left - Probability diagram of enclosed settlement produced by author from new dataset. Right - Probability diagram for enclosed settlements from Noble et al. (2013: Figure 7: 1146).

Finally, a probability distribution diagram displaying the dates for fortified settlements was produced (**Figure 11**). Ecclesiastical enclosures were not included in this diagram, as they represent a different process to the other enclosed settlements discussed. This model indicates a distinct period of fortified enclosure construction beginning c.AD400, with a stable distribution of dates through to c.AD800, differing from the model created by Noble et al. (2013), which shows a steep decline in the distribution of dates from the mid-late 6th century. One reason for this difference, and a flaw with the model produced here, is that a high proportion of dates come from the two sites which have been extensively excavated by the University of Aberdeen, Rhynie and Burghead, potentially 'drowning' out the sites with fewer dates. However, these more recent excavations have also produced substantial evidence for activity in the 7th and 8th centuries AD, which was not represented in the previous dataset. This once again demonstrates how new material can quickly change chronologies, and further supports the above assessment that rather than a substantail decline in sites from the mid-6th century, there was change in the sites in use, with new sites being occupied. In Chapter 6 probability diagrams, their flaws (and solutions), will further be discussed.

5.1.2 Other Settlements & Sites

Figure 12 models other settlement types including broch sites, multiperiod settlements and crannogs. In general, these align with the trends identified in Chapter 4. For example, dates returned for the brochs of Gurness (cal AD420-550) and Keiss (cal AD410-540) align with Mackie's (2011) argument that the modification and reuse of brochs in Atlantic Scotland abruptly ceased in the mid-6th century AD, along with the disappearance of Middle Iron Age material culture. Whilst the other settlements also returned dates from the mid-1st millennium AD, without a larger sample and more contextual information limited further interpretation is possible. This is also true for the three burial sites which were included in the dataset, all of which returned mid-1st millennium dates, aligning with the dates expected for these burial types, as discussed in Maldonado (2013). Whilst further analysis is undoubtedly required on the changes in burial practice throughout this crucial period, a larger dataset is required.

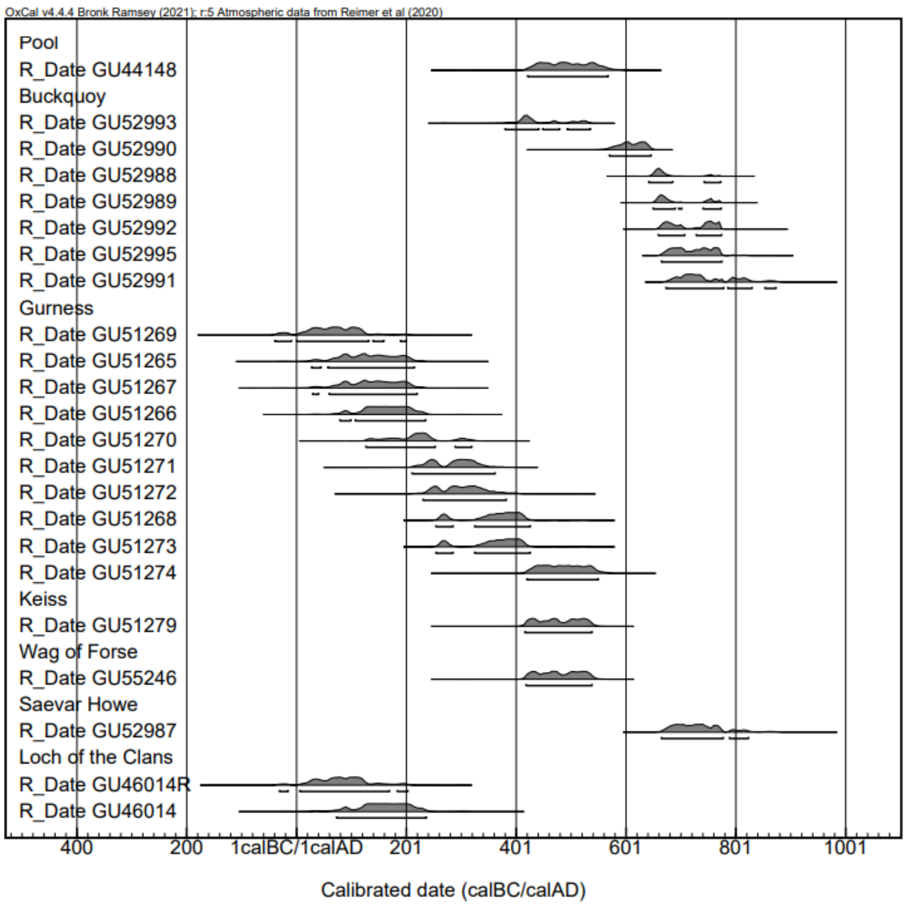

Figure 12: Dates from settlements including brochs (Gurness, Keiss and Saevar Howe), multiperiod sites (Buckquoy and Pool); and the crannog site of the Loch of the Clans. Produced by author in OxCal 4.4.

5.2 SUMMARY

Whilst further analysis is required, several interesting trends contemporary with the AD536 climatic downturn are observable. Primarily, the trends noted by Noble *et al*. (2013) remain evident in this increased dataset, however, crucially, beyond a potential consolidation of power at a smaller number of enclosed settlements by the 7th century AD, there appears to be considerable discontinuity between sites occupied in the 5th-6th centuries, and those which are occupied after c.AD600. How this may relate to the AD536 downturn, and the other trends identified in the previous chapters, will be discussed in the following section.

6. DISCUSSION

The previous chapters have identified several key transformations in the archaeological record of early medieval Scotland, dating between the 5th and 7th centuries AD. However, we must be cautious in associating these changes directly to the mid-6th century climatic downturn. Whilst climatic and environmental changes have the potential to trigger cultural and social shifts, this link is not simple and deterministic, and even where correlation is established, causation is not assured. Indeed, an additional challenge here is the nature of the Scottish archaeological record and the difficulty in determining whether these shifts coincide with the AD536 climatic downturn, owing to the potential for radiocarbon dates to 'smear' changes through time. However, a challenging topic is not unworthy of study, and, despite these challenges, it is possible to draw some preliminary conclusions.

It is worth once again emphasising the impact and severity of the AD536 climatic downturn. Far from a brief 'event', this cluster of volcanic eruptions caused a severe temperature decline of up to 4^{o}C, lasting close to fifteen years, with the climate likely not completely recovering until the 7th century (Büntgen *et al*. 2016; Strachan *et al*. 2019). Whilst it is unknown whether the atmospheric 'dust-veil' itself reached Scotland, this is likely irrelevant, as the cooling the downturn caused is shown in tree-ring chronologies, both from Scotland and neighbouring regions. This temperature decline, and particularly the shorter and cooler growing seasons, would likely have had a severe impact on northerly agricultural societies, which already operated in more marginal conditions. This is clear from the impact of this event in Scandinavia, and it seems unlikely such an event, which had considerable duration, would not have been felt by the peoples of early medieval Scotland. However, exactly what impact this had would have been determined by a range of underlying social and cultural factors, and this need not have been a 'disaster'.

Here it is briefly worth considering the impact of a similar climatic downturn in Scotland, from a more recent and better documented period. The Little Ice Age, c. 1300-1850 AD, whilst longer in duration, shares several characteristics with the AD536 event. The Little Ice Age was likely also caused by a complex coincidence of factors, including a cluster of volcanic eruptions, and was not consistent throughout, with shorter, decade long cold and stormy spells interspersed with warmer periods (Rydval et al. 2017; Dodgshon 2005). Studies have found that this had a considerable impact on Scotland, initiating the abandonment of land due to increased marginality and sand inundations, famines and population decline, and economic and political shifts which are argued to have led to the eventual unification of Scotland with England (Dodgshon 2004; 2005; Parry 1978; 1981; Bampton *et al.* 2017; D'Arrigo *et al.* 2020). The processes underlying these changes were of course complex, however this demonstrates that intense cooling episodes have the potential to have a considerable impact on the environment and societies of Scotland.

As such, the results from the previous two chapters will now be brought together and discussed in relation to the AD536 event. A major transformation occurred in this period, and whether or not these changes can be directly dated to the mid-6th century, it seems likely that the significant climatic degradation must have had an impact on these processes, or conversely, these ongoing social processes would have influenced the resilience of the peoples to degrading conditions. These relationships are complex, and definite conclusions cannot yet be drawn; however, this is clearly a relevant and significant field for future research.

6.1 BRINGING THE RESULTS TOGETHER

The review of previous archaeological literature, presented in Chapter 4, demonstrates that wide ranging shifts occurred in the 5th-7th centuries AD, with many of these appearing to centre on the mid-6th century. These shifts include the abrupt end to oak cultivation, a long-term strategy and investment requiring a high-level of organisation; a peak in the occupation of crannogs, with several being founded in the late 6th century; the end of middle Iron Age culture in Atlantic Scotland; the appearance and proliferation of formal burials and cemeteries; and finally the changes in fortified settlement patterns. The patterns in enclosed settlement discussed in Chapter 4, are further strengthened by the data analysis (Chapter 5), which suggests discontinuity between those sites which were occupied in the 5th and 6th centuries, and those which are subsequently occupied. The coincidence of such a broad range of factors, all showing significant change at roughly the 6th/7th century boundary, is indicative of major social and cultural shifts.

Whilst the exact timing of these processes, and how they relate to the mid-6th century climatic downturn, is difficult to pin down due to broad error ranges given by radiocarbon dates, these shifts do not have to be directly dated to the mid-6th century to be related to this event. The impact that climatic changes can have on societies are complex, potentially accelerating processes already underway or instigating entirely new ones, and often the impact can be drawn out or lag significantly after the event itself (Costanza et al. 2006; Torrence & Gratton 2002). However, we also cannot uncritically associate these changes with the climatic downturn, as the drivers behind cultural change are diverse and complex. An additional challenge here is the way we interpret, analyse and present large samples of radiocarbon dates, with probability distribution diagrams in particular a problematic method of analysis.

6.1.1 Probability Distributions

Probability distribution models were included in a number of the studies reviewed in Chapter 4 (Noble et al. 2013; Maldonado 2013), and one was also produced from the data analysed in Chapter 5 to model the radiocarbon dates for fortified settlements through the 1st millennium AD. However, there are several known issues with this type of modelling, making their interpretation difficult (Kerr & McCormick 2014; Maldonado 2013). Primarily, they are majorly influenced by the shape of the radiocarbon calibration curve, tending to smear dates across preceding and succeeding centuries, and can be further skewed by the inclusion of a large number of dates from one site. This is an issue in the diagram produced in Chapter 5, where a large proportion of dates come from the extensively excavated sites of Rhynie and Burghead, whilst other sites are represented by significantly fewer dates. This creates a challenge for archaeologists analysing a large dataset of radiocarbon dates, as the resulting probability diagrams are highly open to subjective interpretations.

Recent studies on raths in Ireland, the equivalent of Scottish settlement enclosures/ringforts, have produced a methodology which may counter these issues, by combining probability diagrams with Bayesian modelling and considering the influence of the underlying calibration curve (Kerr & McCormick 2014). This method also accounts for the number of dates from each site and has been successful at better modelling the chronologies of rath construction and use in Ireland (Sullivan et al. 2021; Kerr & McCormick 2014). Unfortunately, applying this methodology to the enclosed sites of early medieval Scotland, or even just the dataset under consideration here, would be a substantial undertaking, and indeed warrants a new study in itself. However, future studies on the enclosed settlement of Scotland, and other site types from Scotland, such as crannogs and burials, should utilise this method.

Employing this method in future studies will allow for a better assessment of the distribution of site types through time and will be important not just for considering the impact of the AD536 event, but also for the archaeology of early medieval Scotland more broadly. However, whilst the models produced here, and those discussed from previous scholar's work are flawed, they are not altogether without merit, when approached with caution. Where applied in analysis of raths in Ireland, whilst the new methodology has refined the distribution of dates, the general distribution originally produced through simple probability distributions largely stayed true (Kerr & McCormick 2013: Figures 1 and 7). As such, these models should not be discounted altogether, especially where they show significant distribution trends, however, the smaller peaks and troughs, such as those identified in Maldonado (2013), should not be given too much weight.

However, another result of the data analysis undertaken here demonstrates that just modelling trends in site type through time will not identify all changes in site distribution. The data for enclosed settlements reviewed here, suggests that there may be discontinuity in sites occupied from the 5th-6th centuries, and those occupied from the 7th century onwards. Whilst the probability diagram, and likely even a diagram modelled in accordance with the method discussed above, shows a relatively stable distribution of sites in the 5th, 6th, and 7th centuries, (in contrast to the model utilising a smaller dataset produced by Noble *et al.* 2013), this dows not show that the sites occupied before and after c.AD600 are different. This demonstrates the importance of undertaking a wide range of analysis on data, as cultural change can be expressed in highly variable ways. Of course, it remains possible that the sites identified here as starting in the 7th century do have origins in the earlier centuries, as suggested by Noble (*et al*. 2013; 2019b), however, further research is required to test this hypothesis.

6.2 CENTRALISATION AND THE RISE OF KINGDOMS

Whilst a number of trends can be roughly dated to align with the AD536 event, the question remains of what these changes represent, and how they may relate to the climatic downturn. This period (c.AD400-600), in Scotland, has increasingly been understood as transformative, with both the archaeological and historical sources indicating the emergence of increasingly complex systems of rulership and social structures (Noble 2019b). These processes are often linked to the changes wrought by the withdrawal of Rome, the introduction of Christianity, and as part of a pattern of change occurring in the wider European sphere; culminating with the rise of overkingships from the early 7th century, and the eventual unification of Scotland under the kingdom of Alba.

The recent work by the University of Aberdeen, focused primarily on Northern Pictland, has further demonstrated the transformative nature of this period, with the abandonment of important and powerful sites like Rhynie (cal AD 510-560) suggested to be linked with these shifts in power and rulership (Gondek & Noble 2019). However, whereas Noble et al. (2013) found that the building of enclosed settlements appeared to slow from the mid/late 6th century, with activity continuity at a smaller number of larger sites, the increased dataset further shows discontinuity between the sites used before and after c.AD600. Further work, including Bayesian modelling, as well as further excavation, will be required to confirm this hypothesis, particularly as many of these sites are represented by only a few dates, and if such a division does exist, further analysis may show it to occur sometime before or after AD600, or be drawn out. Additionally, as evidenced by the establishment of upland settlements such as Lair in Glen Shee, following climatic amelioration at the beginning of the 7th century, we must also consider the role that the 'end' of this downturn may have had in the settlement patterns and transformations of this era, with the current chronological resolution making it difficult to separate these processes (Strachan *et al*. 2019).

As such, it appears that the 6th century may have been a key period of social change in Scotland, or at least Pictland, whereby a centralisation of power led to the abandonment of old sites, the establishment of new ones, and potentially the rise of a new, smaller and/or more powerful elite. Whilst it is possible that these processes may have been in progress prior to the AD536 event, it seems likely that this major climatic downturn, which may have contributed to the abandonment of sites through failed harvests and increased social unrest, either triggered or accelerated these processes, perhaps allowing some members of the elite to further consolidate their power. Here, a comparison to the evidence from Scandinavia may allow us to better understand these processes.

6.3 COMPARISON TO SCANDINAVIA

The patterns identified here share several significant similarities with the impact of the downturn in Scandinavia. One key impact of the AD536 event in Scandinavia, alongside the substantial abandonment of settlements, depopulation, reforestation, and hoarding activity, is a centralisation of power and the rise of a new elite. Both the burial and settlement record of Scandinavia show significant evidence for discontinuity, as new settlements were founded on higher ground from the mid-6th century (Löwenborg 2012; Gräslund and Price 2012). It has been argued that this largescale abandonment of land increased private ownership, as an elite few were able to acquire large landholdings, leading to the emergence of an increasingly stratified social order and the rise of an aristocratic class. This represents a significant shift in the social structure of southern Scandinavia, as a new political structure arose focusing on elite ownership of land, new types of monumentalised cemeteries and settlements, fortified sites, and the powerful elite manors and the central places which go on to characterise the late Iron Age in Scandinavia.

It is arguable that similar processes can be seen to have occurred in Scotland. In Scandinavia, some of the processes discussed above appear to have origins prior to the downturn, however accelerated and intensified following the crisis, and it is possible that a similar process occurred in Scotland. In Scotland too, roughly following the AD536 event, there is a discontinuity in sites, and the rise of a smaller and more powerful elite who form overkingships such as that of Fortriu. Whether the downturn caused famine, and the abandonment of sites and general social unrest allowed for the rise of these elites, will require further analysis, however, it is well known from both history and the present that in times of crisis select members of society are able to benefit (Löwenborg 2012).

However, whilst the evidence for discontinuity between sites, and the rise of a more powerful elite broadly aligns between the two regions, there are also some notable differences in the material from Scotland and Scandinavia. Crucially, whilst in Scandinavia, particularly in Sweden, there is clear evidence for abandonment of land and significant population decline, so far there is no evidence for such a dramatic 'crisis' in Scotland. Whereas Scandinavia frequently shows evidence for reforestation, Scotland shows the opposite, with the end of oak cultivation practices (Tipping *et al.* 2007), and where environmental studies have been undertaken, even where sites have been abandoned the landscape appears to have continued to be utilised, with agricultural activity even increasing in some cases (Jones et al. 2020; 2022). As these sites are located in the relatively fertile region of Aberdeenshire they may not reflect the situation in other regions of Scotland, where land may have been abandoned, however, further studies would be required to determine this. Indeed, the failures in other regions may have resulted in an increase in activity in the more forgiving northeast. Additionally, just because land was not abandoned does not mean that crops did not fail for several years during the downturn, and the hardships caused by these failures may still have contributed to the social shifts evidenced in the archaeological and historical material. Further work is required to better understand the environmental and agricultural impact of this event in Scotland; however, the question remains as to why Scandinavia shows a more distinct and severe population crisis.

There are a number of potential factors which could underlie the supposed difference in the impact of the AD536 event in Scotland and Scandinavia. One of course lies in the nature and scale of archaeological research conducted in the two regions, with a much more extensive record from Scandinavia allowing for a higher level of resolution. However, an additional and intriguing factor, worthy of further consideration, is the evidence for the impact of endemic ergotism on the predominantly rye crops of central Sweden (Bondenson & Bondenson 2014). This fungus, which thrived in the colder and wetter conditions of the downturn, has impacts not only in mortality of both humans and livestock, but longer lasting demographic effects in reduced fertility. Whilst there is evidence for ergotism in the areas of Sweden most severely impacted by the AD536 event, there is as yet no evidence for such an outbreak in Scotland. Whilst ergot is known to have existed in Scotland since the Bronze Age, it has not been found in any early medieval archaeological context, possibly as rye, the cereal most susceptible to ergot, was not the predominant crop in this period (Duncan 1993; Barclay 1984).

This is one potentially significant factor which may underlie the differences in resilience between Scandinavia and Scotland, however other social, cultural and environmental factors could also be at play. Once again, it must also be acknowledged that the impact of the AD536 event was far from consistent within Scandinavia and the Baltic itself, with many regions, particularly Northern Norway, Northern Sweden, and Finland, appearing to show substantially more resilience to this event, likely due to their lower reliance on agriculture (Tvauri 2014; Wallin 2014). This may also be the case within Scotland, and further comparison between regions will be essential in future research.

6.4 BURIAL AND BELIEF

Whilst the settlement evidence suggests major changes in the 6th century AD, the burial material is less clear. Whilst Maldonado's (2013) probability distribution diagrams did show shifts in the mid-6th century, these peaks and troughs may be a result of the shape of the radiocarbon calibration curve. As such, going forward it will be necessary to apply the methods discussed above (Kerr & McCormick 2013) to better understand these processes. Additionally, as with the enclosed settlements discussed above, it will be necessary to consider the distribution of each individual site through time, to identify whether there is continuity or discontinuity with the burial sites used through this period. However, the emergence of formal cemeteries in the 5th to 7th centuries AD, has also been connected to the emergence of the new type of kingship discussed above. These formal cemeteries, which frequently reused or associated themselves with ancient monuments have been suggested to represent ways marking and communicating legitimacy and formal ties to land and inheritance (Noble 2019). This once again demonstrates the complexity and interconnectedness of these processes.

Additionally, future research should consider the impact of the AD536 on the belief systems of early medieval Scotland, as this may offer an intriguing avenue for future research. This event is thought to have left its mark in Norse mythology (Gräslund and Price 2012) and in Scotland, this period is characterised by a major change in belief as by the early 7th century AD, Christianity appears to become well established, with the founding of major monasteries such as Iona c.AD563 (Maldonado 2019; Evans & Noble 2019). Whilst the process of conversion was likely complex and multidimensional, future research should consider the potential role of the AD536 event in these processes. It stands to reason that in times of hardship and crisis, as possibly occurred during the mid-6th century downturn, when one's old belief appears to be offering no respite from the suffering, people may be more receptive to a new religion which promises a heavenly afterlife and a reward for a lifetime of suffering.

6.5 COMPARISON TO IRELAND

Ireland, alongside Scandinavia, is the region most commonly chosen for comparison to Scotland. These three regions share a considerable number of characteristics including their location on the periphery of the Roman Empire, relatively marginal agricultural conditions, and a wide range of similar archaeological characteristics. Compared to Scotland, Ireland has the benefit of a considerably better excavated archaeological record due to extensive developer led excavations, as well as more extensive contemporary historical sources. Indeed, in the years immediately following the AD536 event, there are two mentions of 'failures of bread' in the Irish annals, and several tree ring chronologies from Ireland demonstrate the significant climatic impact of the event (Baillie 1995). Despite this, as in Scotland, little work has assessed the impact of this downturn in Ireland.

The Early Medieval Ireland Project, a seminal work collating and analysing the archaeological evidence from all site types, found that the mid to late 6th century AD was a period of dramatic and rapid change (O'Sullivan *et al*. 2021). From the mid-6th century, Ireland appears to have witnessed a rapid growth in population, an increased sophistication in agriculture and economy, changes in long distance trade and exchange, a proliferation in the building of crannogs, and the origination of raths, the enclosed farmsteads that characterise this period in Ireland. Additionally, documentary sources suggest that the great majority of ecclesiastical and monastic sites were founded in the mid-6th century, with Baillie (2007) suggesting this points to a memory the decade of AD540 as a new beginning in the Celtic Church. These changes have been linked to possible political and social upheaval, with the defensible settlements suggesting an uneasy population. This period also sees the political expansion of the Ui Neill dynasties, and it has been suggested that this may have been a particularly violent time. Whilst the authors do briefly mention the AD536 climatic deterioration potentially leading to crop failures, famine, and plagues, they suggest that the impact of such events on society is debatable, moving on to a discussion of the Justinian plague, which, as previously discussed, is not so easily separable from the AD536 downturn (O'Sullivan *et al*. 2021).

Thus, whilst this period appears to also have been one of significant change in Ireland, there are considerable differences between how these changes are expressed compared to Scotland and Scandinavia. It is notable that Ireland witnesses' population growth in this period, contrary to what occurred in some regions of Scandinavia. Additionally, whilst raths proliferate in Ireland from this period, their equivalent in Scotland, ringforts, begin to decline. However, both Scotland and Ireland see an increase in crannog construction, and all three regions appear to see political expansion and the rise of more stratified social structures. Of course, how exactly the changes in Ireland relate to the AD536 event will require further study, however, its impact should not be dismissed so readily.

6.6 RESILIENCE AND VULNERABILITY

The mid-6th century was a period of significant change in Scotland, Scandinavia, and Ireland, however, there is considerable diversity in how these changes are expressed. The extensive archaeological works undertaken both in Scandinavia and Ireland, mean that these transformations are more narrowly dated to the mid-6th century AD than they are in Scotland, and as more work is undertaken in Scotland it will be interesting to see whether a similar pattern arises. However, whilst in Scandinavia it is perhaps more straightforward to associate these trends with the AD536 climatic downturn, due to the substantial abandonment of land and decreased population, this is not so clear in Scotland and Ireland. In Ireland, the growth of population may indicate a different set of processes, however the direct dating of so many changes to the mid-6th century is significant, and these differences, and comparisons between these regions, provide incredibly interesting and potentially vital avenues for better understanding the resilience of these past societies. In Scotland, whilst further resolution is required, this too is clearly a period of significant transformation.

Whilst further work is required to establish exactly how the climatic downturn factored into these changes, the coincidence of dramatic, but contrasting, changes across three distinct geographical regions, may be indicative of an external environmental driver rather than a primarily social one. Crucially, the diversity in the way these changes are expressed demonstrates that the impacts of environmental downturns are not simple, nor restricted to a single trajectory, rather being determined by a range of geographical, environmental, social and cultural factors. Far from a simple 'crisis' it appears that this downturn impacted the regions on the periphery of north-western Europe in incredibly diverse ways, emphasising the complexity of the human-climate dynamic and the importance of considering all factors as interrelated when considering past cultural change.

However, to better understand these complex relationships, much more comprehensive analyses will be required. This was not a comprehensive dataset of 1st millennium dates, but rather a sample, and most dates analysed here came from the fortified settlements of Pictland. Future research should consider dates from throughout Scotland, accounting for Scotland's diverse topography and climate, and allowing for differences in severity of the impacts felt as well as in social resilience. The ongoing Scottish Tree Ring project (Wilson et al. 2011) which is building a dendrochronology for the Cairngorms, will contribute significantly to our understanding of the climatic impacts of this event in Scotland, however, further regional paleoenvironmental studies will add greater nuance.

As such in future research, far more detailed, and crucially **regional** analyses will be necessary to better understand the impacts of the AD536 climatic downturn in Scotland. As well as these analyses being more regional in focus, it will be necessary to examine a significantly wider range of factors, beyond site type, to better understand these impacts. These should include site size and location; examining landscape positioning, relative fertility of land, as well as what we know about the peoples and ongoing processes of the regions. Furthermore, the construction of a detailed, regional, picture of 6th century Scotland will allow for more detailed comparison between these regions, and with Ireland and Scandinavia. Only through doing this will we be able to properly understand the complex processes ongoing in the mid-6th century AD. Indeed, we must also allow for future research finding that in some regions, or in Scotland overall, the AD536 downturn was not a factor of change at all, providing vital research avenues for better understanding this resilience. Only through untangling these complex climatic and cultural processes can we begin to better understand the transformations of the mid-1st millennium.

6.7 SUMMARY

As such, this study has identified several key transformations which point to the mid-6th century as being a fundamental period of change in early medieval Scotland. Changes in land use, material culture, burial practices and settlement patterns are all indicative of disruptions and changes to the ongoing social systems of this period, which is increasingly recognised as a key period in the rise of early kingdoms. The coincidence of these major transformations, not only in Scotland but in neighbouring Scandinavia and Ireland, and the AD536 event, which may have had dramatic implications for northerly agrarian societies, is significant. Whilst further research is undoubtedly required to better understand these complex processes, we clearly can no longer consider these environmental and cultural factors as separate. It is crucial that we study such events and seek to better understand the complex and dynamic mechanics of resilience and vulnerability. This is important not only to our understanding of past societies ability to weather environmental change, but also of how we might in modern times, something we are quickly running out of time to do.

7. CONCLUSION

This study is the first work to review and bring together the evidence for the impact of the AD536 event in Scotland and has barely scraped the surface of what is necessary to fully understand these processes. Nonetheless, it has clearly demonstrated that this will be a fruitful and integral avenue of future research, and crucial to our understanding of the complex processes of 1st millennium AD north-western Europe. Here, a wide range of trends have been identified which date from the 5th-7th centuries AD, including changes in the environment, burial practices, belief, and settlement. The 5th-7th centuries are increasingly recognised as a key period of change in early medieval Scotland, with the few historical records available suggesting dynamic social processes including the rise of more centralised forms of power, and the data analysed here further suggests discontinuity in enclosed settlement around the turn of the 6th/7th century. Whilst these exact processes are poorly understood, together they clearly represent disruption to the ongoing social systems of this period. Of course, further work will be necessary to refine the chronological relationship between these changes and the downturn, however, these climatic changes must be considered as a factor at play in these complex transformations.

The coincidence of major changes in Scandinavia, Ireland and Scotland, around the mid-6th century AD demonstrates that something significant occurred in this period, and the AD536 event was likely a critical factor. Whilst previous research has often highlighted social causes for these changes, generally related to the fall of the Roman Empire, the narrow dating of these changes in both Ireland and Scandinavia, which benefit from better chronological resolution, may support the climatic downturn as a key driver. Crucially, the patterns in these three regions, whilst sharing similarities, are distinct, and in each of these regions the climatic downturn is associated with a complex and variable set of processes and transformations, which were undoubtedly determined by environmental, social, and cultural factors. This emphasises the cultural and social element to how societies are impacted by, and respond to, environmental changes, a result which is far more interesting than simple and deterministic relationships. Thus, by discussing the impact of climatic downturns, we are not ignoring or discounting social and cultural drivers of change, but rather illuminating them. As we increasingly recognise that the nature-cultural divide is a western and modern construct, we must concede that these processes are inseparable, in the past as they are today. To ignore environmental factors is not to the benefit of our understanding of the social and cultural processes, but rather to their detriment.

This conceptual shift will be crucial in future research on the impact of the AD536 event. Whilst the material reviewed here came from throughout Scotland, and the data analysed was primarily from Pictland, future work must undertake regional analyses on the diverse environment and peoples of early medieval Scotland. In Scandinavia, different regions were differentially impacted by the downturn, and this is likely also the case in Scotland. Only through identifying these different impacts can we begin to untangle the environmental, political, and cultural factors behind this variance. Indeed, this may even allow us to better understand, currently poorly defined, differences between the kingdoms and peoples of early medieval Scotland. To understand these regional variations a broader range of factors will need to be considered, with analysis going beyond site type, to consider site location, landscape positioning and size, and the relationship between these factors and changing climate over broader timescales. Finally, future research should utilise improved analytical techniques to approach the increasing body of radiocarbon dates.

The almost complete absence of the AD536 event in the Scottish discourse, especially when it has been so prominent in Scandinavian archaeology for over ten years, is notable. Whilst the relatively short duration of this event may make its impacts difficult to identify in the vague and 'smeared' chronologies of early medieval Scotland, even when events are securely dated contemporary to the climatic downturn, it is rarely addressed, and when it is, it appears almost immediately dismissed. This is at the detriment of not only our understanding of this complex and transformative period in Scotland, but also of the factors determining resilience, something which could prove crucial in the present day.

Indeed, we no longer have time for largely unfounded sensibilities, which highlight cultural factors at the detriment of environmental ones, with human driven climate change rapidly accelerating (IPCC 2022; Cassidy & Mani 2022). Additionally, even more directly relevant, we also face the looming risk of future extreme volcanic eruptions. Researchers suggest that due to the disturbance to ocean and atmospheric circulation caused by climate change, a large-magnitude eruption in the tropics, like that of the AD536 downturn, could cause 60% more cooling in the next century compared with today, with the frequency of eruptions also likely to increase (Aubry *et al.* 2021; 2022). A *Nature* article released days before the submission of this dissertation highlights that we are woefully unprepared for such an event, highlighting the need to identify regions of heightened vulnerability and exposure and ramp up both preparedness and community awareness (Cassidy & Mani 2022).

Archaeologists can contribute to both of these challenges in a number of ways. Firstly, the past acts as a laboratory, full of data which we would have no time to collect from the present, aiding climate scientists, volcanologists, and policy makers in understanding the regional and diverse impacts of such events. Additionally, through the communication of our findings, archaeologists are uniquely positioned to reduce psychological distance and increase awareness of climate change, especially to those thus far 'buffered' from its effects (Britton & Hillerdal 2019). Finally, we can offer hope, as the archaeological record testifies to the ability of human societies to respond creatively and successfully to episodes of climatic stress (Mitchell 2008). As such, as well as improving our understanding of the past, research into events such as the AD536 downturn, may prove crucial in our understanding of the regional and social impacts of large tropical eruptions. This may be vital in building future strategies, and the communication of this event to the public, going beyond the catastrophising that has characterised its depiction in the past, may inspire and frame our future. Thus, research of such events provides a rare opportunity for archaeologists to not only better understand the past, but to aid in the creation of a future in which we can continue our valuable work.

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9. APPENDICES

9.1 APPENDIX 1: CAUSE OF AD536 CLIMATIC DOWNTURN

The initial explanation for the AD536 climatic downturn, and the dust-veil described in the Mediterranean sources, was one, or multiple, large volcanic eruptions. Large and violent volcanic eruptions expel large amounts of ash, hydrochloric acid, and sulphur dioxide into the atmosphere, much of which falls back to the earth relatively quickly. However, sulphur dioxide mixes with water to produce fine sulfuric acid aerosols which, if they reach the stratosphere, can dim incoming sunlight on a hemispheric or even global scale for multiple years, lowering the earth's surface temperature and backscattering solar radiation (Newfield 2018). As such, a large stratospheric volcanic eruption would align with the dust-veil described in historical sources, as well as with the climatic downturn observed in tree-ring records.

However, Hammer (1984) later redated the acidity signals seen in the Greenland Dye-3 ice-core, and subsequent ice-cores found no evidence for a significant volcanic signal in the vicinity of 536-545 AD. This led Baillie, a leading scholar who through dendrochronological analysis had identified the significant climatic downturn and cooling evident in tree-ring records, to explore other potential causes of this event (Baillie 1994; 1995; 1999; 2007). Baillie suggested that the climatic downturn, dust-veil and cultural changes observed in this period were the result of one or multiple extra-terrestrial impacts, potentially on one of the world's large oceans (Baillie 1999; 2007). However, following the publication in 2008 of new ice-cores (Larsen *et al*. 2008) with evidence of two large volcanic eruptions dating to 539±2 and 533-544±2, Baillie (2008) retracted his theory. Rather, Baillie (2008; 2010) proposed that there was a fault in the dating method for the ice-cores and that they required redating by seven years, resulting in a two stage AD536 - 550 environmental downturn with an initial large northern eruption in AD 536 which caused the dust-veil observed in the Mediterranean, and a secondary, larger, eruption closer to the equator in AD540-1. This aligned with the two-stage cooling event demonstrated by the tree-ring records, whereby the impacts were only seen in the northern hemisphere prior to AD540, with the event becoming global after this date. This was confirmed in further studies, finding that the largest two downturn eruptions were comparable to the strongest eruptions of the last 1200 years, and smaller, but still large eruptions occurring around AD545/6 and 550/1, further exacerbated the climatic impacts (Sigl *et al.* 2015).

Whilst a volcanic cause is now largely undisputed, the specific volcanoes that erupted is still unknown. Mount Churchill, Alaska; Rabaul, Papua New Guinea; Krakatau, Indonesia; El Chichon, Mexico; Ilopango, El Salvador and Haruna, Japan, have all been nominated by various authors (Newfield 2018). Whilst Baillie has withdrawn his impact theory, and a primarily volcanic cause is likely, there is some evidence from the GISP2 core and radiocarbon dating from the formation of the Gulf of Carpentaria in Australia that suggests an impact may also have occurred (Abbott *et al*. 2008). The complexity of the cause of the climatic downturn goes somewhat towards explaining its unusual impact, duration, and regional variability.

9.2 APPENDIX 2: OUTLINE OF SITES

9.2.1 Hillforts

9.2.1.1 Dundurn, Perthshire

Canmore ID: 24873

Dundurn, Perthshire, is an early medieval fortification with a upper ‘citadel’ on the rocky summit, with further ramparts enclosing a series of lower terraces (Lock & Ralston 2017: SC2625). The upper citadel, described as ‘dun-like’ in the atlas of hillforts measures 25m E-W by 20m transversely (0.04ha), with a triangular enclosure on the uppermost terrace enclosing an area of 85m from E-W by 50m (0.4ha) and the lower walls/terraces enclosing a total area of 2ha (Lock & Ralston 2017: SC2625). The site was excavated by Leslie Alcock in 1976-7, opening ‘keyhole’ trenches focusing on the citadel and uppermost terrace, collecting radiocarbon dates, which led Alcock to suggest a sequence beginning in the 5th or 6th centuries AD with a palisade, followed by the construction of the citadel and the expansion of the terraces, with several phases of building and remodelling. There is one historical mention of the site in the Annals of Ulster, which refer to a siege of Dundurn in AD683 (Noble *et al*. 2013: supplementary information). Radiocarbon dates from these excavations were submitted for dating as part of Noble *et al*. (2013) review of the fortified settlements, included in the current database.

9.2.1.2 Abbey Craig, Stirling

Canmore ID 4711F3

Abbey craig is a hillfort, into which the Wallace Monument has been built. The western flank is formed by a cliff edge, and the eastern rampart forms a bank up to 10m in thickness and 1m in height, enclosing an area measuring 53m from NNE-SSW by 38m transversely (0.16ha) with a second rampart 30m beyond this line (Lock & Ralston 2017: SC1592). Several phases of community-based excavations targeted the ramparts, identifying a possible third rampart, and producing radiocarbon dates, though these have also examined later Edwardian and Victorian activity (Cook 2019). Recent dates obtained in 2018 targeted the middle rampart, confirming it to be timber laced, with radiocarbon dates from the core returning late dates which indicate it could be one of the last forts in Scotland (Cook 2019). These dates are included in the current dataset. The earlier dates were not attained for this research however returned dates suggesting the inner rampart was constructed in cal AD500-780 (Cook 2019).

9.2.1.3 Urquhart Castle, Inverness-shire

Canmore ID: 12547

Urquhart Castle, the site of a 13th century stone castle, is also the location of an earlier fortification. This site was also excavated as part of Alcock's programme of keyhole dating of Pictish sites mentioned in historical sources, with Alcock suggesting that the early medieval fortification could be the 6th century fort mentioned in Adomnán's Life of Columba (Noble *et al*. 2013: supplementary information; Alcock & Alcock 1992). As such, excavation has been limited, focusing on the high rocky boss, uncovering a cobbled surface, paved floors, hearths, and a revetment of boulders which may have once been the foundation of a rampart or enclosing wall, though some view this evidence as unconvincing (Lock & Ralston 2017: SC2879). As such, the exact plan and extent of the defences is unknown, though the summit likely measured 40m NNE-SSW by 15m, enclosing an area of no more than 0.05ha (Lock & Ralston 2017: SC2879). A larger enclosure may have enclosed an area measuring 140m NE-SW by 50m (0.5ha), however excavation is required to confirm this (Lock & Ralston 2017: SC2879). Radiocarbon dating suggested activity began in the 5th or 6th centuries AD, continuing into the early second millennium. Dates from these excavations were included in Noble *et al*. (2013) review of fortified enclosures and are also included in the current dataset.

9.2.1.4 Norman's Law, Fife

Canmore ID: 31814

Norman's Law is a complex nuclear fort with views over the Firth of Tay, comprised of four separate enclosures. The innermost oval enclosure measures 53m from E-W and 29m transversely (0.13ha), with an entrance in the ENE (Lock & Ralston 2017: SC3144). The second (western) enclosure measures 100m from E-W by 65m transversely (0.52ha), but this is likely a subdivision of a larger enclosure which measures internally 215 from E-W by 75m transversely (1.22ha), with an entrance along the southern side, however the exact configuration of the various enclosures and their access is largely unknown (Lock & Ralston 2017: SC3144). The outermost defences follow natural terraces to enclose an area measuring 350m from ENE-WSW by 190m transversely (5ha), with an entrance on the south with a trackway leading to the large summit enclosure (Lock & Ralston 2017: SC3144). A number of hut circles have been identified in the various enclosures. Excavations by the University of Aberdeen in 2021 targeted three of the ramparts including the upper citadel and two of the lower enclosures, with samples collected for radiocarbon dating included in the current dataset.

9.2.1.5 Balbinny, Angus

Canmore ID 34793

Balbinny is a circular enclosure with a diameter of c. 80m enclosing a low hilltop, overlooking a group of Pictish symbol stones in Aberlemno and a possible barrow cemetery (O'Driscoll & Noble 2020). In 2018, excavations were undertaken by the University of Aberdeen across the southern side of the enclosure, revealing the cut of the ditch as well as the entrance terminal and the edge of a possible entrance post. Samples were taken from the ditch fills for radiocarbon dating, included in the current dataset (O'Driscoll & Noble 2020a). Further excavations were undertaken in 2020 and 2021.

9.2.1.6 Craig Dorney, Aberdeenshire

Canmore ID: 17275

Craig Dorney is an oval nuclear fort with a rampart enclosing an area measuring 70m NE-SW by 28m transversely (0.25ha) (Lock & Ralston 2017: SC2943). In the NE a second line forms a narrower terrace and further down slope a ditch extends around the NE, SE and SW flanks, enclosing an area of 90m by 48m (0.38m). The interior is largely featureless, and the position of the entrance is unknown (Lock & Ralston 2017: SC2943). It is possible that the fort has origins in the Iron Age, with later Early Medieval reuse. Excavations were recently undertaken by the University of Aberdeen with a single sample of charcoal collected for radiocarbon dating included in the current dataset.

9.2.1.7 Dummiefarline, Perth and Kinross

Canmore ID 49618

Dummiefarline fort is set on a rocky hillock and has been heavily robbed. The defences likely originally consisted of an inner enclosure measuring 25m E-W by 14m transversely (0.03ha), and an irregular outer rampart enclosing terraces to the east and west of the summit, measuring 64m in length and tapering to 20m in the east and 14m in the west (0.1ha) (Lock & Ralston 2017: SC3202). The entrance of was likely in the west, and some vitrified stones were recovered by RCAHMS investigators (Lock & Ralston 2017: SC3202). Recent excavations by the University of Aberdeen collected a number of charcoal samples from floor layers for radiocarbon dating, included in the current dataset.

9.2.1.8 Craig Phadrig, Inverness-shire

Canmore ID: 13846

Craig Phadrig is a hillfort, located just outside Inverness, with defences comprising two walls with an internal area of 72m NE-SW by 22m (0.18ha) (Lock & Ralston 2017: SC2896). It was excavated in the 1970s by Small and Cottam, and two phases of occupation were identified (through both artefactual material and radiocarbon dating) – the first in the Iron Age, and the second in the early medieval period, with a significant hiatus between (Lock & Ralston 2017: SC2896). The exact phasing of the defences is unclear however the outer circuit may be the earliest fortification, enclosing an area of 120m from NE-SW by 60m (0.6ha) (Lock & Ralston 2017: SC2896). There also appear to be events of burning, reconstruction, and vitrification (Lock & Ralston 2017: SC2896). Dates from these excavations were included in Noble *et al.* (2013) review of fortified enclosures and are also included in the current dataset.

9.2.1.9 Clatchard Craig, Fife

Canmore ID: 30074

Clatchard Craig, Fife, a hillfort in Fife was almost completely destroyed by quarrying in the 1950s, however, prior to its destruction extensive excavations were carried out (Lock & Ralston 2017: SC3125; Close-Brooks 1986). Whilst originally thought to be an Iron Age enclosure, dating from the excavations produced 1st millennium AD dates for the enclosures seven defensive ramparts. The upper ramparts enclosed a small summit 'citadel' which measured 73m ESE-WNE by 27m transversely (0.18ha) and the ramparts returned radiocarbon dates between AD 290 and 880, with floor surfaces within the upper citadel returning finds dating to the 8th century (Lock & Ralston 2017: SC3125). Further ramparts enclosed an upper terrace which measured 90m E-W by 67m transversely (0.46ha), returning a radiocarbon date of AD430-660. A final terrace enclosed an area of 115m ESE-WNW by 79m transversely (0.68ha) returning dates of AD430-770 (Lock & Ralston 2017: SC3125). All the ramparts appeared to have stone facing and timber lacings. Recent excavations by the University of Aberdeen have produced new radiocarbon dates for this site, which have been combined with previous dates in the current dataset.

9.2.1.10 Hill of Barra, Aberdeenshire

Canmore ID: 19668

This site is a multivallate fort with three phases of construction, with an ovular inner rampart enclosing an area which measures 122m from E-W by 95m (0.92ha) (Lock & Ralston 2017: SC2981). The two outer ramparts and ditches enclose an area of c. 155m E -W by 125m transversely (1.54ha), with entrances likely at all four cardinal points (Lock & Ralston 2017). The site was excavated as part of Murray Cook's programme of keyhole dating in Aberdeenshire, targeting the defences, and recovering charcoal samples from the primary fills of two of the ditches with the inner ditch dating to 560-260BC and the latter to AD380-580, demonstrating that the fort had an Iron Age origin with early medieval reoccupation and remodelling, involving the insertion of a ditch between the two outer Iron Age banks (Cook 2011b: 215-216). These radiocarbon dates were included in Noble *et al*.s (2013) review of fortified enclosures and are also included in the current dataset

9.2.1.11 Dumyat, Stirling

Canmore ID: 47117

Dumyat, or Castle Law (335m OD) is located on a spur to SW of the summit of Dumyat, creating a promontory fort defended to the NE, SE and SW by cliffs and steep slopes falling away virtually to sea level (Lock & Ralston 2017: SC1593). There is an oval enclosure on the summit, with two further previously unknown ramparts cutting off the only accessible approach from the west, identified by Stirling Archaeology and AOC Archaeology in 2014 (Cavers 2015). The inner enclosure measures 27m by 16m (0.03ha) and the outer defences enclose an area measuring 95m by 50m (0.4ha). There are ruins of several other walls within the interior, as well as further external enclosures. Some vitrified stone has been found associated with both the inner and outer ramparts (Lock & Ralston 2017: SC1593). The Atlas of Hillforts states that it is likely that the inner enclosure was inserted into the interior of an earlier fort, and the hill bears a placename derived from the ancient tribal grouping of the Maeatae (Lock & Ralston 2017: SC1593). Fieldwork undertaken in 2019 by the University of Aberdeen confirmed the ditches identified in 2014 and a radiocarbon sample was taken for dating from one of these ditches, included in the current dataset.

9.2.1.12 Migvie, Hopewell Lodge, Aberdeenshire

Canmore ID 16999

Migvie is a small fort on a low glacial ridge, composed of two ramparts measuring up to 1m in height with external ditches barring access from the NW. Satellite imagery shows an interior of 45m by 25m (0.13ha) (Lock and Ralston 2017: SC2936). Excavations undertaken by the University of Aberdeen recovered the radiocarbon dates included in the current dataset.

9.2.1.13 Craig Rock, Fife

Canmore ID: 340454

Aerial photography first identified the remains of a small fort, with a single rampart, on the summit of Craig Rock, enclosing an area measuring c. 50m by 17m, c. 0.07ha (Lock & Ralston 2017: SC4229). In 2019, the University of Aberdeen excavated five trenches in the central citadel, revealing substantial ramparts on the northern and southern sides of the fort, and clear evidence of occupation within the fort (Noble *et al*. 2020b). Finds including crucible fragments, a spindle whole, an iron blade, and a shale bead were recovered from midden deposits against the northern rampart. Evidence for sub-rectangular stone and turf buildings and occupation spreads were also uncovered. Radiocarbon dating samples from animal bone found within an occupation layer are included in the current dataset.

9.2.1.14 Mither Tap, Bennachie, Aberdeenshire

Canmore ID: 85507

Mither Tap, Bennachie is a hillfort with occupation dating to the 1st millennium AD, with similar morphology to other early medieval 'nuclear forts' (Noble et al. 2013: Supplementary information). Located on the rocky summit, an encircling wall measures 8m in thickness, with several phases of walling, enclosing an interior citadel of c. 0.06ha, and the outer enclosure 0.67ha (Lock and Ralston 2017: SC2961). In 2006, during path-upgrading by Forestry

Commission Scotland, occupation layers were identified dating to the 5th to 8th centuries AD at the entranceway to the fort (Atkinson 2007). The University of Aberdeen has undertaken several recent excavations as well as LIDAR survey at the site, collecting radiocarbon dates included in the samples here (Noble *et al*. 2020a; Mann *et al*. 2015).

9.2.1.15 Glenduckie, Fife

Canmore ID: 30060

Glenduckie is an irregular enclosure, located on the SW spur of Glenduckie hill, with a cliff-edge along its NW flank. The fort is defended by a single rampart and a probable external ditch (now only visible in the north-east), with an interior measurement of 128m from NE-SW, and a maximum of 47m transversely, enclosing a total area of 0.46ha (Lock and Ralston 2017: SC3122). There is an entrance on the north-east and a possible secondary entrance in the south-west. The only internal feature is a likely later, stone walled settlement (30m diameter), enclosing a smaller enclosure (15m diameter) in the south-west (Lock & Ralston 2017: SC3122; O'Driscoll & Noble 2020b). Two trenches were excavated by the University of Aberdeen in 2019, both on the smallest enclosure, revealing its inner facing as well as a single occupation layer abutting this facing, and a pre-bank surface below (O'Driscoll & Noble 2020b). Charcoal and animal bone, as well as a shale bracelet were recovered from these surfaces, with a radiocarbon sample taken from the upper surface, included in this dataset.

9.2.2 Ringforts

9.2.2.1 Maiden Castle, Aberdeenshire

Canmore ID: 18182

Maiden Castle is a ringfort on the slopes of Bennachie, Aberdeenshire, with two successive fortifications consisting of an outer enclosure measuring 40m E-W, overlain by a heavily robbed, circular, stone walled enclosure, 20m in diameter and 2.5m thick (Cook 2011a; Lock & Ralston 2017: SC2962). Excavations undertaken by Murray Cook as part of his keyhole excavation programme (The Hillforts of Strathdon Project) revealed the remains of a possible rectilinear building, postholes, midden layers, cobbled surfaces in the interior, as well as evidence that a wider settlement existed outside the enclosure with evidence for metalworking and manufacturing. Finds included a glass bead, early medieval crucibles, decorated glass (Cook 2011a). These excavations returned dates from the 5th to 7th centuries

AD, and in the current dataset they have been combined with results from more recent University of Aberdeen excavations.

9.2.2.2 Rob's Reed, Angus

Canmore ID 33776

Rob's Reed is a ringfort, located on the same ridgeline as the bivallate fort, oblong fort, and three ringforts located on Turin Hill. Survey and sample excavation were undertaken by the University of Aberdeen as part of the Comparative Kingship project in 2017 and 2018, finding similarities in size and morphology to the those on Turin Hill (O'Driscoll & Noble 2020c). The ringfort has a total diameter of 32m (0.079ha), enclosing an area with a diameter of 16m (0.024ha), with an entrance likely located in the south (O'Driscoll & Noble 2020c). The excavations opened a single trench against the southern inner bank, finding a collapsed bank with in-situ bank core at lower levels, however this was not bottomed due to features against the bank face. The bank was faced by thin slabs, and floor layers were discovered abutting the upper levels of the bank, and a possible hearth feature was also uncovered (O'Driscoll & Noble 2020c). Radiocarbon dates from these excavations are included in the current dataset.

9.2.2.3 Turin Hill, Angus

Canmore ID 34899

Turin Hill, Angus, is the location of a complex of five sites including one large bivallate hillfort, which is truncated by a later and smaller oblong fort, with three smaller ringforts lying along the summit (O'Driscoll & Noble 2020c). The largest bivallate hillfort has an internal area of 2.91ha, and covers an area of 4.68ha total, with a possible entrance in the north. The oblong fort enclosed an area of 0.31ha with a total footprint of 0.67ha, with its wide stone wall ranging from 7.9 to 13m wide (collapsed). The ringforts enclosed 0.023ha (0.085ha total); 0.045ha (0.09ha total) and 0.01ha (0.104ha total) respectively. The University of Aberdeen undertook geophysical survey (2017) as well as small scale excavation (2018), targeting the defences of each of these enclosures, with radiocarbon samples being taken for dating from four of the five (the bivallate hillfort and the three ringforts), included in the current dataset (O'Driscoll 2018b; O'Driscoll & Noble 2020c; O'Driscoll & Noble 2020d). The bivallate hillfort was the earliest of the enclosures, with a likely pre-c.400 cal BC date. Whilst dates were not attained from the oblong fort, as it truncates the bivallate fort it postdates this, and is likely to predate the ringforts. Whilst the ringforts were previously thought to be early medieval in date, the radiocarbon samples returned dates suggesting construction after 400-200BC, and the central example may have remained in use until the first century AD. Rob's Reed, discussed above, is located on the same ridgeline as this complex of enclosures and the sites are likely to be related.

9.2.2.4 Hill of Keir, Aberdeenshire

Canmore ID 19341

A small enclosure or ringfort is located on the summit of the Hill of Keir, enclosing an area of 0.14ha, with the entrance likely originally in the east (Noble 2019c). Excavations were undertaken in 2016 by the University of Aberdeen, with one trench placed in the interior and one over the eastern wall. A possible denuded wall line, and an occupation layer were discovered within the interior, with charcoal recovered from the occupation horizon taken for radiocarbon dating, included in this dataset. The external wall was found to spread up to 2.8m thick, composed of mostly granite stones, and charcoal was recovered for radiocarbon dating from a deposit immediately under the wall core, also included in this dataset (Noble 2019c).

9.2.2.5 Barmkyn of North Keig, Aberdeenshire

Canmore ID: 17701

Located on the summit of the Hill of Arlie, Aberdeenshire, Barmkyn of North Keig is a bivallate stone-walled sub-circular enclosure or ringfort. The inner wall encloses an area of 25-31m diameter, and the substantial stone outer wall has an internal diameter of c.45m, with an entrance in the south-east (Noble 2019; Lock and Ralston 2017: SC2955) Excavations and survey were conducted in 2017 as part of the University of Aberdeen's Northern Picts project, with two targeting the outer wall and the interior (Noble 2019c). The surviving wall was found to have a height of 0.5m, composed of rounded stones of granite, sandstone and schist, with a maximum thickness of 3m (Noble 2019c). A linear spread of charcoal and a possible post-hole were also discovered, with charcoal sampled from both of these features, as well as from possible hearth-waste, taken for radiocarbon sampling, all returning late 1st millennium BC dates (Noble 2019). These dates are included in the dataset used here.

9.2.2.6 Cairnmore, Aberdeenshire

Canmore ID: 17723

Cairnmore, located on Hare Hill near Rhynie, Aberdeenshire, is a double banked sub-oval stone enclosure, or ringfort, with an additional external ditch and rampart at its south-eastern entrance, measuring c. 64m by 48m externally, with an internal area of 52m by 46m (0.19ha) (Cook 2011b; Lock & Ralston 2017: SC2956). In 2010 excavations were conducted, opening ten trenches which returned radiocarbon dates which indicated that the enclosure was both constructed and destroyed between 410-630 cal AD (Cook 2011b; Lock & Ralston 2017: SC2956). Two medieval brooch moulds and a pin mould were recovered, and it was suggested that the inner rampart may have been destroyed by fire and subsequently robbed (Cook 2011b). In 2018 and 2019 further excavations were undertaken by the University of Aberdeen, further targeting the ramparts as well as the interior of the fort, identifying hearth features and postholes which appeared to form a revetment for the inner stone bank (Noble et al. 2019d; Noble et al. 2020d). A charcoal sample from the upper house floor, taken in the University of Aberdeen excavations was sent for radiocarbon dating and is here combined with pre-existing radiocarbon dates for Cairnmore in the current dataset.

9.2.3 Coastal Promontory Forts

9.2.3.1 Burghead, Moray

Canmore ID: 16146

Burghead is the location of a substantial coastal promontory fort, which includes an extensive sculptural assemblage, unique bull plaques, and an intriguing well structure. Mid-18th century plans show the fort consisted of three ramparts with ditches, cutting off the headland from the southern shore (Lock & Ralston 2017: SC2925). The construction of the village and harbour resulted in extensive demolition of the ramparts, so Roy's plan, published in 1703, is integral to our understanding of the original fortifications. The fort includes an upper and lower citadel, and the summit enclosure measured at least 155m ESE to WNW by 60m transversely (0.8ha) with an entrance in the ESE end, whilst the entire fort covered an area of around 5.5 hectares, making it the largest Pictish fortified site known (Lock & Ralston 2017: SC2925; Noble 2019b: 46). The site has undergone multiple excavations in antiquity, revealing that the intricate and substantial fortifications, with more recent work by Edwards and Ralston (1978) and Ralston (2004) providing valuable chronological and environmental information for the rampart construction and dating (Noble 2019b: 47). Recent work by the University of Aberdeen has obtained further material for radiocarbon dating, which has been combined with the previous dates in the current dataset.

9.2.3.2 Cullykhan, Aberdeenshire

Canmore ID: 19942

Cullykhan is a large promontory fort with several Iron Age phases, with a summit measuring 260m by 20-70m (c.1ha) (Lock & Ralston 2017: SC2982). A smaller rectilinear enclosure measures 54m by 30-48m (0.25ha) (Lock & Ralston 2017: SC2982). The site was excavated between 1963 and 1972 by Colvin Greig and though the precise chronology remains unclear, several Iron Age phases were identified, as well as evidence of early medieval reoccupation (Lock & Ralston 2017: SC2982). A layer of cobbling returned a 1st-millennium AD date, a ditch was assigned to a similar phase on stratigraphic grounds, and a large wooden object with iron fittings was dated to the 5th-6th centuries AD, suggesting a Pictish phase of occupation to this fort. Dates from Cullykhan were included in Noble et al. (2013) review of fortified enclosures and are also included in the current dataset

9.2.3.3 Portknockie, Moray

Canmore ID: 17408

This site is a promontory fort, with a complex history of occupation. Excavations in the 1970s and 1980s by Ian Ralston (Ralston 1987) revealed a burnt timber-framed wall of early medieval date enclosing an area of 120m NE to SW by 30m (0.28ha), only 70m x 15m (0.09ha) of which makes up a relatively level summit (Lock & Ralston 2017: SC2945). This wall overlay an earlier palisade trench, with sub-rectangular buildings and earlier floor surfaces also discovered, some of which likely date to the Iron Age, with Bronze Age pits also identified (Lock & Ralston 2017: SC2945). Finds included pottery, mould fragments, jet bracelet and ring fragments, a glass ring and bowl furnaces (Lock & Ralston 2017: SC2945). Radiocarbon samples from these excavations were included in Noble *et al*.'s (2013) review of fortified enclosures and are also included in the current dataset

9.2.3.4 Barns Mill, Fife

Barns Mill is a coastal promontory fort, identified by cropmarks, located above the Caiplie Caves which have crosses and two Pictish symbols carved into the walls (Lock & Ralston 2017:

SC3172). Four concentric defensive ditches form a belt 33m deep, cutting off an area which measures 100m from NE-SW by 50m transversely (0.4ha) with a further interior rampart which encloses an area of 0.35ha (Lock & Ralston 2017: SC3172). Excavations undertaken by the University of Aberdeen recovered material for radiocarbon dating, included in the current dataset.

9.2.3.5 The Gegan, East Lothian

Canmore ID: 57866

The Gegan is an isolated sea stack, 65m from the coast, which was first identified by antiquarian investigation with excavations undertaken in 1870s by J W Laidlaw, discovering a foundation wall with associated midden, though no remains are now visible on the surface (Laidlaw 1870). Finds were recovered from these excavations including objects of bone, needles, pins, a dress fastener, a comb with Pictish symbols, and Roman amphora (Laidlaw 1870; Lock & Ralston 2017: SC3921). Whilst the sea stack, which now measures 45m E-W by 18m N-S, is no longer connected to the mainland, it is possible it was once a promontory fort or coastal settlement which erosion has separated from the mainland (Noble *et al*. 2020c). In 2019 excavations were undertaken by the University of Aberdeen, uncovering a possible enclosing wall, extensive midden deposits, a possible drain, and possible stretches of walling (Noble et al. 2020c). Though these excavations tried to identify the structure revealed in Laidlay's excavations, only the backfill from these excavations was found. Animal bone from the midden and the wall core were sampled for radiocarbon dating, included in the current dataset.

9.2.3.6 Blockie Head, Aberdeenshire

Canmore ID: 75948

First noted in the 19th century, Blockie Head is a coastal promontory fort in Aberdeenshire, located on the south side of the entrance to North Haven. At least three ditches (possibly four) enclose its neck on the WSW, with a low internal bank alongside the outermost ditch (Lock & Ralston 2017: SC2987). The interior measures 60m from ENE-WSW by 8-13m transversely, with the entrance, a central causeway, in the WSW (Lock & Ralston 2017: SC2987). Excavations were undertaken in 2019 by the University of Aberdeen targeting the inner ditch, second ditch and over the entrance, where two large postholes were discovered, possibly representing a palisade (Noble *et al*. 2020f). A trench was also placed in the interior where further postholes and a floor layer were discovered. Samples from these excavations are included in the current dataset.

9.2.4 Lowland Enclosures

9.2.4.1 Aberlemno, Angus

Canmore ID: 34861

Aberlemno village, and the area surrounding is the location of the finds of three Pictish symbol stones (Canmore IDs: 34862; 34863; 34806). The University of Aberdeen has undertaken of geophysical surveys in the area (O'Driscoll 2018a), as part of the Comparative Kingship project and undertook subsequent excavations where potential settlement had been identified, with excavations in 2022 discovering a Pictish symbol stone. Several samples were recovered for radiocarbon dating, included in the current dataset.

9.2.4.2 Rhynie, Aberdeenshire

Canmore ID: 17199

The village of Rhynie is characterised by being the find location of a number of Class I Pictish symbol stones. One of these stones, the Craw Stane, remains roughly in-situ in a field to the south of the village, and resistivity work in 2005 and 2006 identified the traces of multiple enclosure surrounding the stone. Subsequent excavations revealed a unique lowland enclosed settlement, with substantial defences, and with evidence of high-status imported goods and potential ritual activity, set in a highly ritualised landscape (Gondek & Noble 2019; Noble *et al*. 2019a; 2019b). Radiocarbon dates collected as part of this project are included in the current dataset.

9.2.5 Crannogs

9.2.5.1 Loch of the Clans, Highland

Canmore ID 15206

The Loch of the Clans is a crannog site, c.20m in diameter, sitting at the edge of a bog which was once a large loch (Stratigos 2018). A number of antiquarian excavations were undertaken in the 19th century, and this combined with the drainage of the loch has significantly impacted the preservation of the site. Excavations were undertaken in 2017 by the University of

Aberdeen, collecting a roundwood sample for radiocarbon dating, included in the current dataset (Stratigos 2018).

9.2.5.2 Loch Vaa, Highland

Canmore ID: 15385

The site is an artificial island located on Loch Vaa, with a diameter of c.15m. An archaeological evaluation, in the form of survey and test-pitting was undertaken in 2019 to assess the impact of low water levels on the site, as the crannog was increasingly exposed above the surface of the loch, potentially putting any surviving organic material at risk (Stratigos 2020). Eighteen timber structural elements, all horizontal, were identified in underwater survey, with two trenches also recovering organic deposits and structural material (Stratigos 2020). Radiocarbon samples were taken from these timbers, included in the current dataset.

9.2.6 Settlement and Broch Sites

9.2.6.1 Gurness, Orkney Islands

Canmore ID 2201

Gurness is a complex settlement, centred on the Broch of Gurness which is encircled by three walls with external ditches. The site was extensively excavated in the 1930s (Hedges 1987). The broch is c. 10m in diameter, with walls 4.4m thick which survive at 3.6m in height and has an entrance in the east flanked by guard cells, and includes mural chambers, galleries, a well, stairways and a scarcement (Lock & Ralston 2017: SC2860). The surrounding settlement has partially encroached on the outermost defences, resulting in the destruction of the innermost wall and its replacement with an irregular curtain (Lock & Ralston 2017: SC2860). The interior of the enclosure measures 44m E-W by 37m transversely (0.14ha), though in the north some may have been lost to coastal erosion. The sequence of construction is unknown, and the inner and/or outer enclosures may be either associated with the construction of the broch or could alternatively predate it (Lock & Ralston 2017: SC2860). The surrounding settlement includes likely Pictish and later Viking period buildings, including a Pictish house with five cells surrounding a central living room, a large oblong house, and a female, likely Scandinavian, grave (Hedges 1987). A likely 6th/7th century Pictish cross-slab was also discovered on top of the broch wall. Samples of animal bone from the 1930s excavations, including from the broch and outbuildings, have been submitted for radiocarbon dating by the University of Aberdeen, included in the current dataset.

9.2.6.2 Keiss Broch/Hillhead Broch/The Pap, Highland.

Canmore ID: 9182

'The Pap', near Broadhaven in Wick, Caithness, was excavated by Sir Francis Tress Barry in the early 20th century and represents a probable solid based broch. There is little evidence from these investigations, with modern interpretations of the broch relying on a single plan and several photographs from these excavations. Externally the broch measured c. 16.8m, the internal court measured c. 9.15m, the average height of the interior wall face was 2.7m with a main entrance facing east. The broch featured guard cells, passages, staircases and several later extensions and additions. The design of the entrance passage is unusual for a broch, however this may be due to poor recording. Finds included awls, needles, bone dice, red deer antler and sandstone whorls and discs, as well as small sherds of pottery (Mackie 2007). The finds suggest a standard middle Iron Age broch assemblage however the inclusion of a composite bone comb suggests that the site continued in occupation, with the high wall pulled down, until the late Iron Age period (7th century). Also found was the top of a human skull into which three small perforations had been placed in a rough equilateral triangle. A sample of this skull fragment was submitted for radiocarbon dating.

9.2.6.3 Wag of Forse, Highland

Canmore ID: 8608

Wag of Forse is a multiperiod settlement comprised of a broch and a series of later structures, including circular cellular buildings and a number of aisled longhouse structures, known as 'wags'. These unusual galleried dwellings are found at a number of sites in Caithness and whilst assumed to be Pictish in date, were not directly dated until recently (Mackie 2007). The site was previously excavated between 1939 and 1948 by Alexander Curle, and in 2019 the University of Aberdeen undertook excavations alongside the Caithness Archaeological Trust and Dunbeath Heritage Museum, collecting dates from the Wag structures, included in the current dataset.

9.2.6.4 Saevar Howe, Orkney Islands

Canmore ID: 1835

Saevar Howe is a large sandy hillock, which was excavated by Farrer in 1862 and 1867, revealing a building, overlaid by a long-cist Christian cemetery. The building yielded finds typical of broch culture, with a well-built wall enclosing a flagged yard. One of the cists excavated contained a Celtic bell, known as the Bell of Birsay. Other finds included human skull fragments, a small clay urn, a fragment of the lower jaw of a pig, ox bone, two cut bone pins and a portable whetstone. In 1977 limited rescue work was undertaken by John Hedges who found the mound had three phases, with earlier fragmentary Pictish buildings, later Viking period buildings and the final long cist cemetery (Hedges 1983). A fragment of animal bone from the assemblage was sent for radiocarbon dating by the University of Aberdeen, included in the current dataset.

9.2.6.5 Sandwick, Unst, Orkney Islands

Canmore ID: 141

Sandwick is a bay on Unst, the northerly most island of the Shetlands. In the 1970s a Norse farmstead was excavated by Gerry Bigelow, with continued use into the late 15th century, as well as two square burial cairns of 1st millennium date (Bigelow et al. 1980; Bigelow 1984). A further Norse farmstead was excavated in 1995. Excavations between 2004 and 2007 by SCAPE trust and Guard Archaeology focused on a mound to the south of the original farmhouse, finding a complex, multi-phase, cellular late prehistoric building, with a burial cut into windblown sand covering the structure (Lelong & Shearer 2004; Lelong 2006; 2007a; 2007b). The burial returned a radiocarbon date of AD130-390, indicating the building had gone out of use by this date (Lelong 2007b). A radiocarbon date from human bone is included in the current dataset.

9.2.6.6 Pool, Sanday, Orkney Islands

Canmore ID: 3422

Located on the island of Sanday, Orkney Islands, Pool is a multi-period settlement ranging from the Neolithic to the Norse period. Excavations occurred in the 1980s discovering cellular late iron age structures riveted into earlier Neolithic deposits (Hunter 2007). This structure appeared to have gone out of use during the Pictish-Norse interface prior to the construction of probable Norse structures. A souterrain type structure was also uncovered, as well as significant Neolithic material. A Pictish symbol stone, lying face down as a paving stone was also found during excavations in 1985, and the archaeological context of the stone was radiocarbon dated to the mid-6th century. An Ogham inscribed fragment was also discovered.

9.2.6.7 Buckquoy, Orkney Islands

Canmore ID: 1802

Buckquoy is a settlement located on the Orkney Islands, opposite the Pictish and Norse site of the Brough of Birsay. Buckquoy was excavated in the 1970s by Anna Ritchie, uncovering a low long mound which covered the remains of five structural periods dating from the 8th to the early 10th centuries, though this dating was stratigraphical, based on a Viking skeleton of the late 10th century being inserted into the mound created by the ruined buildings below (Ritchie 1979; Morris & Barrowman 2021). Below the burial were the remains of three successive Norse long-houses, a hall structure, which in turn overlay a likely Late Iron Age/Pictish structure incorporating both circular and sub-rectangular elements. Beneath this was an earlier phase represented by the remains of a celled building, associated with triangular headed bone pins. A long cist burial was radiocarbon dated to AD390-580. This site has significance to our understanding of the poorly understood Viking/Pictish interface. The burial radiocarbon dates were reviewed as part of the Brough of Birsay project (Morris & Barrowman 2021). Newly processed radiocarbon dates from animal bone recovered in the 1970s excavations have been included in the current dataset.

9.2.7 Ecclesiastical Sites/Vallums

9.2.7.1 Kinneddar, Bishops Palace, Moray

Canmore ID: 16459

New work at Kinneddar, Moray has identified a substantial vallum enclosure. Also the location of a significant early Christian sculptural assemblage, excavations in 1936 by boys from Gordonstoun School focused on the foundation of the Bishop's Palace, with subsequent work by CFA Archaeology, further investigating the same structure. However, excavation by Headland in 2002 revealed a large ditch to the east of the Bishop's Palace which was identified as a possible enclosure ditch surrounding the Bishop's Palace or modern graveyard, however likely reflected a northern stretch of the vallum (Noble et al. 2018). In 2015-2017 new work was undertaken by the University of Aberdeen as part of the Northern Picts and Comparative Kingship projects, with development-led work by AOC Archaeology occurring in the same period (Noble *et al*. 2018). Geophysical survey identified a large vallum enclosure surrounding an area of up to 8.6ha, with a similar ground plan to major sites such as Iona. Subsequent excavation was undertaken revealing post-holes, floor layers, and the likely two successive phases of the vallum represented by two ditches. The primary ditch had a depth of 1.3m and width of 1.5m and the secondary ditch had a depth of 0.9m and width of 5m. A possible annexe enclosure was also identified. The AOC evaluation also excavated parts of the vallum ditch. Radiocarbon dating from these excavations suggest the site was in use from the 7th century through to the 12th century when it first appears in historical records. It is likely that Kinneddar was a major ecclesiastical site in the early medieval period, with its similarities to Iona perhaps indicating a connection with the Columban church (Noble et al. 2018) Dates from these excavations are included in the current dataset.

9.2.7.2 Dunkeld, Perth & Kinross

Canmore ID: 346595

In 2018, the University of Aberdeen undertook 12.4ha of magnetic gradiometry survey in the area to the immediate north of Dunkeld Cathedral (O'Driscoll et al. 2020). This was undertaken to identify any possible enclosing elements associated with the cathedral that might indicate the presence of an early ecclesiastical settlement or church associated with the Pictish symbols previously found on the site. The survey revealed a complex series of features including a curved band to the NW of the cathedral, truncated in the south and east by the remains of old Dunkeld town which was burnt down and abandoned in 1689. Subsequent excavation collected a charcoal sample from the upper fill of this ditch, included in the current dataset.

9.2.7.3 Glamis, Angus

Canmore ID 365075

In 2019, a ditch was identified by geophysical survey (gradiometry and electric resistance) in the NE of field behind Kirkwynd Street in Glamis (Noble et al. 2020e). This ditch was identified as a potentially part of a vallum and curved with a NW to SE alignment, running towards the Class II Pictish stone (likely 8th century) located at the church manse (Canmore ID 32067). A small trench uncovered a ditch of c.3m width and 1.6m depth, with the fill suggesting the presence of a now levelled internal bank lined with stones. Charcoal samples were taken from the upper and basal fills for radiocarbon dating, included in the current dataset.

9.2.8 Burial Sites

9.2.8.1 Ackergill Links, Highland

Canmore ID: 9243

Ackergill Links is a linear inhumation cemetery in a mound which measures 120m long with a width of up to 27m, and a heigh of 2m. It was excavated in 1925 and 1926 by Edwards who uncovered sixteen burials in ten separate graves, mostly unfurnished long cists. The mound has been considerably truncated by modern features (Edwards 1926; 1927). Excluding one, possibly 10th century bronze chain, no graves goods were found. Two Pictish symbol stones, one ogham inscribed, were also found at the site, one on the surface of the mound. Further excavation was undertaken in 2003 and 2004 after mechanical excavation on the site, with human and animal bone being recovered from spoil heaps and stone structures being recorded (Hunter Blair 2004). A sample for radiocarbon dating of human bone from Ackergill is included in the current dataset.

9.2.8.2 Dairy Park, Golspie, Dunrobin, Highland

Canmore ID: 6567

This site is a long cist, which was discovered overlain by a Pictish symbol stone. Ploughing in 1977 uncovered the stone, and subsequent excavation by Joanna Close-Brooks found that it overlay a low, rectangular cairn covering a long-cisted extended inhumation of an adult female, orientated ENE -WSW (Close-Brooks 1980). The cist was composed of sandstone slabs and had been completely covered by a layer of clean, yellow sand, before a thin layer of pebbles and the kerb of laid boulders. The cairn was estimated to have measured 9.5m by 7m, and c. 0.5-0.6m high. The skeletal material was radiocarbon dated and produced a 7th century date (uncalibrated) consistent with the likely date of the Pictish symbol stone (Close-Brooks 1980). A new sample was submitted for testing, included in the current database.

9.2.8.3 Birsay, Brough Road, Orkney Islands

Canmore ID: 73552

A long cist burial was identified in 1976 due to erosion in the cliff section, leading to small scale excavations (Morris 1989). The long-cist contained two adult skeletons lying N-S, with further excavations in 1978 showing the cist to be associated with an eroded cairn, with underlying body (Morris 1989; Morris & Barrowman 2021). A date from Cairn 2 is included in the current dataset.

9.2.9 Other Sites

9.2.9.1 Sueno's Stone, Forres, Moray

Canmore ID: 15785

Sueno's stone is a huge, 6.5m tall cross-slab. A number of excavations and watching briefs were undertaken as part of the construction of the glass and steel canopy which protects the stone (1991; 1994) and for other works in the area (1996; 2003; 2005). The 1994 excavation established that the stone is set into a socketed, dressed block, and excavated several features including three large post holes, as well as the stubs of smaller wooden posts, likely dating to the erection of the stone (McCullagh 1995). Further truncated pits or postholes were found further away from the stone. Excavations in 1996 found a truncated pit containing burnt wood charcoal (AOC 1996), and the 2005 watching brief attained a single radiocarbon date (c. 100 BC) from a feature, likely associated with a settlement in the area, though not directly related to the stone (Buchanan 2005). Charcoal from these excavations has been dated by the University of Aberdeen and is included in the current dataset.

9.3 APPENDIX 3: RADIOCARBON DATES

9.3.1 Table of calibrated radiocarbon dates

The following table includes all radiocarbon dates from the combined dataset, calibrated to 1σ (68.2% probability) and 2σ (95.4%) probability. The newly attained radiocarbon dates, provided by Gordon Noble (pers comm.) included the $\delta^{13}C$% value, however, the dates from previous studies did not have this information. Context information is included where available, as well as details on the sample material. Each site's dates are ordered by Radiocarbon Age, from oldest to youngest.

Table 4: Calibrated radiocarbon dates for combined dataset. Calibrated in OxCal 4.4 by author.

SITE	LABNO	MATERIAL	CONTEXT	RADIOCARBON AGE (BP)	CALIBRATED 1σ	CALIBRATED 2σ	$\delta^{13}C$%
POOL	GU44148	Animal Bone: Cattle		1570±33	cal AD 430-550	cal AD 420–570	-20.8
SANDWICK	GU45566	Human bone	Sandwick 1	1575±17	cal AD 430-550	cal AD 430–550	-20.4
DAIRY PARK, GOLSPIE	GU45636	Bone, unburnt (metacarpal): Human	long cist	1465±17	cal AD 580-640	cal AD 570–650	-21.3
LOCH OF THE CLANS	GU46014R	Charcoal: *Corylus avellana*	103	1944±30	cal AD 20–130	cal BC 40– AD 210; 0–170 (90.3%)	-29.1
LOCH OF THE CLANS	GU46014	Charcoal: *Corylus avellana*	103	1883±35	cal AD 120 – 210	cal AD 70–240	-29.1
KINNEDDAR	GU48044	Charcoal: *Fraximus sp.*	3022	1704±30	cal AD 260–410	cal AD 250-420	-25.0
KINNEDDAR	GU47110	Charcoal: *Fraximus sp.*	3022	1399±35	cal AD 607–670	cal AD 580–680	-26.1
KINNEDDAR	GU48042	Charcoal: *Ericales*	3020	1370±30	cal AD 640–680	cal AD 600-780	-26.7
KINNEDDAR	GU47107	Charcoal: *Corylus avellana*	3023	1353±35	cal AD 640–760	cal AD 600–780	-26.2
KINNEDDAR	GU48043	Charcoal	3022	1345±30	cal AD 650–760	cal 640–780	-24.8
KINNEDDAR	GU48041	Charcoal: *Ericales*	3004	1286±30	cal AD 670-780	cal AD 660–820	-27.0
KINNEDDAR	GU47108	Animal bone: large herbivore	3012	1211±35	cal AD 780–880	cal AD 680–950	-22.3
KINNEDDAR	GU47851	Charcoal: *Salix sp.*	3020	1129±24	cal AD 890–980	cal AD 770-1000; 870-1000 AD (93.8%)	-26.8
KINNEDDAR	GU47106	Animal bone: Cattle metatarsal	3015	1070±35	cal AD 900–1030	cal AD 890–1030	-22.2
KINNEDDAR	GU47103	Animal bone: Deer mandible	1009	1006±35	cal AD 990-1120	cal AD 980–1160	-22.7
KINNEDDAR	GU47105	Animal bone: large mammal	3003	1003±35	cal AD 990–1130	cal AD 990–1160	-22.0
KINNEDDAR	GU47112	Charcoal: *Corylus avellana*	4007	938±35	cal AD 1040–1160	cal AD 1020–1210	-27.1
KINNEDDAR	GU47111	Charcoal: *Betula sp.*	4011	911±35	cal AD 1040–1210	cal AD 1040-1220	-24.8
KINNEDDAR	GU47104	Charcoal: *Corylus avellana*	1017	900±35	cal AD 1040–1220	cal AD 1040–1220	-25.8
BURGHEAD	UB2208	Organic material including chacoal: *Quercus Robur*	Layer under upper fort western rampart	1690±40	cal AD 260–420	cal AD 240-440 (93.9%)	

SITE	LABNO	MATERIAL	CONTEXT	RADIOCARBON AGE (BP)	CALIBRATED 1σ	CALIBRATED 2σ	δ^{13}C%
BURGHEAD	N329	Charcoal: *Quercus robur*	Western rampart of upper fort	1560±115	cal AD 400–610 (65.8%)	cal AD 240–670	
BURGHEAD	N327	Charcoal: *Quercus robur*	Western shore rampart	1560±110	cal AD 400–610 (67.3%)	cal AD 250-670; 310–670 (90.8%)	
BURGHEAD	GU48153	Charcoal: *Corylus*	1011	1437±24	cal AD 600–650	cal AD 580–660	-30.0
BURGHEAD	GU48152	Charcoal: *Corylus*	1011	1426±26	cal AD 600–650	cal AD 590–660	-30.5
BURGHEAD	GU48528	Human bone: skull		1342±26	cal AD 650–760	cal AD 640–780	-20.1
BURGHEAD	N328	Charcoal: *Quercus robur*	Western shore rampart	1340±104	cal AD 600–830	cal AD 480-980; 530–900 (92.2%)	
BURGHEAD	GU49296	Charcoal: *Betula sp.*	105 Lower citadel upper midden	1313±30	cal AD 660–780	cal AD 650–780	-26.2
BURGHEAD	GU52055	Animal bone: mammal		1309±30	cal AD 640–780	cal AD 650–780	-21.6
BURGHEAD	GU52059	Animal bone: large mammal		1307±30	cal AD 660–780	cal AD 650–780	-22.3
BURGHEAD	GU49297	Charcoal: *Betula sp.*	106 Lower citadel basal midden	1293±30	cal AD 670–780	cal AD 650–780	-24.8
BURGHEAD	GU52060	Animal bone: mammal		1286±30	cal AD 670–780	cal AD 660–820; 660–780 (93.2%)	-23.0
BURGHEAD	GU48155	Charcoal: *Betula sp.*	1028	1275±26	cal AD 680–770	cal AD 660–820	-25.7
BURGHEAD	GU51389	Human bone		1275±26	cal AD 680–770	cal AD 660–820	-20.9
BURGHEAD	GU52058	Animal bone: cattle		1238±30	cal AD 700–880	cal AD 680–890	-22.5
BURGHEAD	GU52061	Animal bone: cattle		1226±30	cal AD 700–880	cal AD 680–890	-22.7
BURGHEAD	GU52057	Animal bone: large mammal		1220±30	cal AD 780–880	cal AD 680–890	-22.1
BURGHEAD	GU48154	Charcoal: *Corylus*	1020	1218±26	cal AD 780–880	cal AD 700-890	-24.7
BURGHEAD	GU52056	Animal bone: large mammal		1161±30	cal AD 770–960	cal AD 770–980	-22.5
BURGHEAD	UB2083	Charcoal: *Quercus robur*	4m below rampart crest, cavity within rampart rubble	1085±40	cal AD 890–1020	cal AD 880-1030	
ACKERGILL	GU51278	human bone: parietal	Skull1905	4708±35	cal BC 3530–3370	cal BC 3630–3370	-20.3
ACKERGILL	GU51277	human bone: maxilla	Maxillae1905	4458±33	cal BC 3370–3120	cal BC 3490–3100	-20.1

SITE	LABNO	MATERIAL	CONTEXT	RADIOCARBON AGE (BP)	CALIBRATED 1σ	CALIBRATED 2σ	$\delta^{13}C$%
ACKERGILL	GU48529	human bone : skull		1541±26	cal AD 440–580	cal AD 430–600	-21.4
CLATCHARD CRAIG	GU48923	cremated animal bone: mammal	Trench B, Level 6	2583±26	cal BC 800–770	cal BC 810-590	-21.0
CLATCHARD CRAIG	GU51388	Animal bone: cattle		1603±24	cal AD 420–540	cal AD 410–540	-22.0
CLATCHARD CRAIG	GU1794	Charcoal: *Quercus robur*	Rampart 1	1560±55	cal AD 430–570	cal AD 400–610 (94.8%)	
CLATCHARD CRAIG	GU1796	Unidentified charcoal	Rampart 2	1475±55	cal AD 560–650	cal AD 430–660; 530–660 (85.8%)	
CLATCHARD CRAIG	GU1797	Unidentified charcoal	Rampart 3	1470±60	cal AD 560–650	cal AD 430–670; 530–670 (84.4%)	
CLATCHARD CRAIG	GU48927	Animal bone: pig	Trench A, Level 7	1456±26	cal AD 590–650	cal AD 570–650	-21.9
CLATCHARD CRAIG	GU48924	Animal bone: cattle	Trench B, Level 7	1452±26	cal AD 600–650	cal AD 570–650	-22.3
CLATCHARD CRAIG	GU48933	Animal bone: cattle	Trench FF, Level 4	1435±26	cal AD 600–650	cal AD 580–660	-22.4
CLATCHARD CRAIG	GU48928	Animal bone: cattle	Trench A, Level 9	1427±26	cal AD 600–650	cal AD 590–660	-21.8
CLATCHARD CRAIG	GU48926	Animal bone: cattle	Trench A, Level 6	1426±26	cal AD 600–650	cal AD 590–660	-22.1
CLATCHARD CRAIG	GU1798	Unidentified charcoal	Rampart 1	1400±55	cal AD 590–670	cal AD 550–780; 550–710 (88.1%)	
CLATCHARD CRAIG	GU48925	Animal bone: large mammal	Trench A, Level 5	1396±26	cal AD 600–660	cal AD 600–670	-22.3
CLATCHARD CRAIG	GU51387	Animal bone: pig		1388±26	cal AD 610–670	cal AD 600–670	-22.5
CLATCHARD CRAIG	GU1795	Charcoal: *Quercus robur*	Rampart 1	1350±75	cal AD 600–780	cal AD 560–880; 560–780 (85.3%)	
CLATCHARD CRAIG	GU48922	Animal bone: cattle	Trench B, Level 3	1347±26	cal AD 650–760	cal AD 640–780	-22.1
DUMMIEFARLINE	GU49288	Charcoal: *Betula sp.*	104 Floor layer	2200±30	cal BC 360–190	cal BC 370–170	-26.3
DUMMIEFARLINE	GU51726	Charcoal: *Alnus cf glutinosa*	304	2171±30	cal BC 260–160	cal BC 360–100	-25.8
DUMMIEFARLINE	GU49289R	Charcoal: *Alnus cf glutinosa*	304 Floor layer	2161±24	cal BC 350–160	cal BC 360–100	-26.2
ROB'S REED	GU49291	Charcoal: *Corylus avellana*	006 Base of hearth	2030±30	cal BC 60– AD 30	cal BC 110– AD 70 (94.8%)	-25.0

SITE	LABNO	MATERIAL	CONTEXT	RADIOCARBON AGE (BP)	CALIBRATED 1σ	CALIBRATED 2σ	$\delta^{13}C$%
ROB'S REED	GU49290	Charcoal: *Alnus cf glutinosa*	003 Late floor	1906±30	cal AD 80–210	cal AD 30–220	-25.4
TURIN HILL	GU49295	Charcoal: *Alnus cf glutinosa*	504 Basal layer on bedrock	2421±30	cal BC 550–420	cal BC 750 – 400	-26.4
TURIN HILL	GU49294	Charcoal: *Betula sp.*	206	2382±30	cal BC 520–390	cal BC 720 – 390	-25.7
TURIN HILL	GU49292	Charcoal: *Betula sp.*	104 E Ringfort slot	2275±34	cal BC 400–230	cal BC 400–200	-25.3
TURIN HILL	GU48388	Animal bone: large mammal	402	2183±25	cal BC 360–170	cal BC 370–160	-21.6
TURIN HILL	GU49293	Charcoal: *Alnus cf glutinosa*	202 Floor layer	1980± 30	cal BC 40– AD 80	cal BC 50 – AD 120	-25.7
MAIDEN CASTLE	SUERC15908	Charcoal	From under bank 2, outer defense	1540±40	cal AD 430–590	cal AD 420–610	
MAIDEN CASTLE	GU49357	Charcoal: *Corylus avellana*	311	1516±21	cal AD 550–590	cal AD 530–610 (94.5%)	-27.5
MAIDEN CASTLE	SUERC22160	Charcoal	From under inner stone wall enclosure	1500±30	cal AD 550–610	cal AD 530–650 (94.6%)	
MAIDEN CASTLE	SUERC15909	Charcoal	Upper fill of ditch 2 backfilled then cobbled	1495±40	cal AD 550–640	cal AD 430–650; 530–650 (88.4%)	
MAIDEN CASTLE	GU49358	Charcoal: *Betula sp.*	904	1365±24	cal AD 640–670	cal AD 610–760; 640–690 (89.9%)	-25.3
ABBEY CRAIG	GU50198	Charcoal: *Alnus cf glutinosa*	201	1219±34	cal AD 780–880	cal AD 680–890	-26.9
ABBEY CRAIG	GU50199	Charcoal: *Corylus avellana*	203	1175±34	cal AD 770–950	cal AD 770–980	-25.9
GURNESS	GU51269	Animal bone: cattle	Phase B/PB(2) Outbuildings general occupation	1955±31	cal AD 20–120	cal BC 40 – AD 210	-21.4
GURNESS	GU51265	Animal bone	Phase B(3) Broch interior final flooring	1910±31	cal AD 80–210	cal AD 20–220	-21.7
GURNESS	GU51267	Animal bone: cattle	Phase B(9) Outbuildings general occupation	1904±31	cal AD 80–210	cal AD 30–220	-22.2
GURNESS	GU51266	Animal bone: pig	Phase B(9) Outbuildings general occupation	1882±31	cal AD 120–210	cal AD 80–240	-21.8
GURNESS	GU51270	Animal bone	Phase PB (1) Broch wall top and upper fill, chambers over entrance	1829±29	cal AD 160–310	cal AD 120–320	-22.7
GURNESS	GU51271	Animal bone: sheep	Phase PB (4) Area NE of S Longhouse	1782±31	cal AD 230–330	cal AD 210–370	-21.9
GURNESS	GU51272	Animal bone	Phase PB(5) North eastern buildings	1762±31	cal AD 240–340	cal AD 230–390	-22.5

SITE	LABNO	MATERIAL	CONTEXT	RADIOCARBON AGE (BP)	CALIBRATED 1σ	CALIBRATED 2σ	$\delta^{13}C$%
GURNESS	GU51268	Animal bone: cattle	Phase B/PB(2) Outbuildings general occupation	1687±31	cal AD 260– 420 (62.6%)	cal AD 250–430	-21.6
GURNESS	GU51273	Animal bone: pig	Phase PB(8) Features to S and SE - Craw's 'D' level paving	1687±31	cal AD 260–420	cal AD 250–430	-21.7
GURNESS	GU51274	Animal bone: antler	Phase PB(8) Features to S and SE - Craw's 'D' level paving	1584±27	cal AD 430–540	cal AD 420–550	-21.4
KEISS	GU51279	Human bone: skull	Skull1866	1607±24	cal AD 420–540	cal AD 410–540	-21.5
BARMKYN OF NORTH KEIG	GU51629	Charcoal: *Quercus sp.*	1901	2239±30	cal BC 380–200	cal BC 400–200	-25.9
BARMKYN OF NORTH KEIG	GU51630	Charcoal: *Quercus sp.*	1903	2165±30	cal BC 360–150	cal BC 360–60	-26.6
GLENDUCKIE	GU51631	Charcoal: *Corylus*	2001	2168±30	cal BC 360–160	cal BC 360–100	-25.6
HILL OF KEIR	GU51633	Charcoal: *Betula sp.*	203	3357±30	cal BC 1730–1540	cal BC 1740–1530	-26.1
HILL OF KEIR	GU51632	Charcoal: *Corylus*	202	2166±30	cal BC 360–160	cal BC 360–60	-25.4
BLOCKIE HEAD	GU51634	Charcoal: *Betula sp.*	2005	2489±30	cal BC 760–540	cal BC 780–480	-27.0
BLOCKIE HEAD	GU51636	Charcoal: *Salix sp.*	301	1894±30	cal AD 120–210	cal AD 70–230	-25.5
BLOCKIE HEAD	GU51635	Charcoal: *Corylus*	4003	1840±30	cal AD 130–250	cal AD 120–320; 120–250 (91.8%)	-27.6
BALBINNY	GU51727	Charcoal: *Corylus*	104 (basel ditch fill)	1564±30	cal AD 430–560	cal AD 420–570	-25.1
BALBINNY	GU51728	Charcoal: *Corylus*	101 (upper ditch fill)	1500±30	cal AD 550–610	cal AD 530–650 (94.6%)	-26.8
LOCH VAA	GU51896	Waterlogged Wood: Betula sp.	Timber_1 (Rings 56-65)	849±26	cal AD 1170–1230	cal AD 1160–1270	-25.5
MITHER TAP	SUERC13465	Charcoal: *Quercus robur*	Occupation layers: under cobbles	1625±35	cal AD 410–540	cal AD 370–550	
MITHER TAP	GU52240	Animal bone: cattle	4005 wall core lower	1381±25	cal AD 640–670	cal AD 600–680	-21.9
MITHER TAP	SUERC13466	Charcoal: *Quercus robur*	Occupation layers: under cobbles	1330±35	cal AD 650-780	cal AD 640–780	
MITHER TAP	GU52927	Charcoal: *Betula sp.*	7003	1284±23	cal AD 670–780	cal AD 660–780	-26.1

SITE	LABNO	MATERIAL	CONTEXT	RADIOCARBON AGE (BP)	CALIBRATED 1σ	CALIBRATED 2σ	$\delta^{13}C$%
MITHER TAP	GU53044	Charcoal: *Betula sp.*	4004	1275±25	cal AD 680–770	cal AD 660–820; 660–780 (92.1%)	-26.1
MITHER TAP	GU52925	Charcoal: *Corylus*	3003	1274±23	cal AD 680–770	cal AD 660–820; 660–780 (94.1%)	-25.3
MITHER TAP	GU52926	Charcoal: *Corylus*	5003	1271±23	cal AD 680–770	cal AD 660–820; 660–780 (91.9%)	-25.6
MITHER TAP	GU52923	Charcoal: *Salix sp.*	212	1269±23	cal AD 680–770	cal AD 670–820	-26.9
MITHER TAP	GU52921	Charcoal: *Betula sp.*	1007	1266±24	cal AD 680–770	cal AD 670–830	-26.2
MITHER TAP	GU52241	Animal bone: mammal	1005 15-30cm SW quadrant lower citadel midden	1263±25	cal AD 680–770	cal AD 670–830	-22.4
MITHER TAP	GU52242	Animal bone: sheep	1005 15-30cm SW quadrant lower citadel midden	1261±25	cal AD 680–770	cal AD 670–830	-22.3
MITHER TAP	GU52924	Charcoal: *Betula sp.*	3003	1258±23	cal AD 680–800; 680–750 (63.5%)	cal AD 670–830	-26.8
MITHER TAP	GU52922	Charcoal: *Pinus*	207	187±23			-27.2
CRAIG ROCK	GU52853	Animal bone: large mammal	2012	1417±30	cal AD 600–660	cal AD 590–670	-22.3
CRAIG ROCK	GU52830	Animal bone: cattle	2003	1368±30	cal AD 640–680	cal AD 600–780; 600–690 (86.4%)	-21.9
BARNS MILL	GU52917	Charcoal: *Corylus*	103	1868±23	cal AD 130–220	cal AD 120–240	-25.6
MIGVIE	GU52919	Charcoal: *Salix sp.*	1006	1329±23	cal AD 650–760	cal AD 650–780	-25.2
MIGVIE	GU52920	Charcoal: *Betula sp.*	1007	1326±24	cal AD 650–780	cal AD 650–780	-25.9
SAEVAR HOWE	GU52987	Animal bone	SH77 SH 115	1272±29	cal AD 680–770	cal AD 660–830	-21.8
BUCKQUOY	GU52994	Animal bone: whale	1976.5	1840±24	cal AD 160-250	cal AD 120–250	-14.1
BUCKQUOY	GU52993	Animal bone	1976.103	1640±21	cal AD 400–530	cal AD 380–540	-12.4
BUCKQUOY	GU52990	Animal bone	1976.49	1461±24	cal AD 590–650	cal AD 570–650	-21.5

SITE	LABNO	MATERIAL	CONTEXT	RADIOCARBON AGE (BP)	CALIBRATED 1σ	CALIBRATED 2σ	$\delta^{13}C$%
BUCKQUOY	GU52988	Animal bone	1970-1976/73 133	1355±24	cal AD 650–680	cal AD 640–780; 640-690 (83.4%)	-22.7
BUCKQUOY	GU52989	Animal bone	1970-1976.46 134	1336±21	cal AD 650–760	cal AD 650–780	-21.6
BUCKQUOY	GU52992	Animal bone	1976.102	1308±21	cal AD 660–780	cal AD 660–780	-21.9
BUCKQUOY	GU52995	Animal bone	1976.114	1284±24	cal AD 670–780	cal AD 660–780	-22.1
BUCKQUOY	GU52991	Animal bone	1976.105	1253±24	cal AD 680–820	cal AD 670–880	-21.4
THE GEGAN	GU54416	Animal bone: mammal	205 lower midden on bedrock	1952±27	cal AD 27–120	cal BC 40 – AD 160 ; 0–130 AD (90.6%)	-21.0
THE GEGAN	GU54417	Animal bone: mammal	905 Animal bone from wall core	1927±27	cal AD 31–200	cal AD 20–210	-21.5
GLAMIS	GU54815	Charcoal: *Betula sp.*	1006 Lowest ditch fill	1079±25	cal AD 900–1000	cal AD 890–1030	-27.6
GLAMIS	GU54816	Charcoal: *Salix sp.*	1004 Upper ditch fill	944±25	cal AD 1040–1160	cal AD 1030–1160	-26.4
WAG OF FORSE	GU55248	Charcoal: *Alnus cf. glutinosa*	2004	2217±27	cal BC 370–200	cal BC 390–190	-26.5
WAG OF FORSE	GU55247	Charcoal: *Betula sp.*	2002	2182±27	cal BC 360–170	cal BC 370–150	-26.6
WAG OF FORSE	GU55246	Charcoal: *Betula sp.*	1010	1603±24	cal AD 420–540	cal AD 410–540	-25.2
DUMYAT	GU55249	Charcoal: *Corylus avellana*	104	1500±24	cal AD 550–600	cal AD 540–640	-27.4
BROUGH ROAD	GU55386	Human bone: rib	BY 78 IO Cairn 2	1572±17	cal AD 430–550	cal AD 430–550	-20.5
SUENO'S STONE	GU55518	Charcoal: *Betula sp.*	A10 F0225	1678±24	cal AD 360–420	cal AD 260–430; 330–430 (85%)	-25.2
SUENO'S STONE	GU55520	Charcoal: *Corylus*	FN031	915±24	cal AD 1040–1180	cal AD 1040–1210	-29.7
SUENO'S STONE	GU55519	Charcoal: *Alnus*	FN031	914±22	cal AD 1040–1180	cal AD 1040–1210	-25.6
CAIRNMORE	SUERC32840	Charcoal: *Corylus avellana*	Burnt deposit on top of rampart 3	1580±30	cal AD 430–550	cal AD 420–560	
CAIRNMORE	GU57959	Charcoal	17001 House floor	1562±24	cal AD 430–520	cal AD 430–570	-25.1
CAIRNMORE	SUERC32839	Charcoal: *Alnus*	Primary fill of foundation cut of rampart 2	1510±30	cal AD 540–600	cal AD 440–640; 530–640 (89.5%)	
DUNKELD	GU57960	Charcoal	1003 Upper (Ditch fill)	1220±24	cal AD 780–880	cal AD 700–890	-25.2
CRAIG DORNEY	GU57961	Charcoal		1564±24	cal AD 430–560	cal AD 430–570	-27.4

SITE	LABNO	MATERIAL	CONTEXT	RADIOCARBON AGE (BP)	CALIBRATED 1σ	CALIBRATED 2σ	$\delta^{13}C$%
ABERLEMNO	GU58311	Charcoal: *Quercus*	2004	1235±21	cal AD 700–830	cal AD 680–880	-24.8
ABERLEMNO	GU58188	Charcoal: *Betula*	2001	983±24	cal AD 1040–1160	cal AD 1030–1170	-27.5
NORMAN'S LAW	GU58322	Animal bone: cattle	1005	2196±22	cal BC 360–190	cal BC 370–170	-21.7
NORMAN'S LAW	GU58321	Animal bone: cattle	1003	2045±24	cal BC 100 – AD 10	cal BC 150– AD 30	-22.6
CULLYKHAN	BM639	Section of Oak stump	Gateway	2347±59	cal BC 550–360	cal BC 750–200	
CULLYKHAN	BM446	Unidentified charcoal	Occupation level	2337±65	cal BC 540–230	cal BC 750–200	
CULLYKHAN	GU2097	Unidentified charcoal	Occupation layer, palisade site	2290±60	cal BC 410–200	cal BC 520–170	
CULLYKHAN	GU2098	Unidentified charred timber	Rampart construction	2060±50	cal BC 160– AD 10	cal BC 200–AD 70	
CULLYKHAN	GU2096	Unidentified charred timber	Rampart construction	2010±60	cal BC 90– AD110	cal BC 180–AD 140	
CULLYKHAN	BM445	Unidentified charcoal	Cobbling: occupation	1633±40	cal AD 400–540	cal AD 260–550; 350–550 (94.1%)	
CULLYKHAN	GU2094	Wooden object	Wooden structure	1540±50	cal AD 430–600	cal AD 420–640; 420–610 (94.2%)	
HILL OF BARRA	SUERC28730	Charcoal: *Alnus sp.*	Fill of ditch assocated with inner enclosure	2405±35	cal BC 540–400	cal BC 750–390	
HILL OF BARRA	SUERC28728	Charcoal: *Alnus sp.*	Primary fill of ditch	1615±35	cal AD 410–540	cal AD 400–560	
CRAIG PHADRIG	N1124	Peat and turf	Within outer rampart	2320 ±105	cal BC 720–200	cal BC 770–150	
CRAIG PHADRIG	N1112	Unidentified charred timber	Below rubble adjacent to inner rampart	2280±100	cal BC 470–170	cal BC 750–50	
CRAIG PHADRIG	N1120	Unidentified charred timber	Outer rampart section	2250±100	cal BC 410–160	cal BC 750–40	
CRAIG PHADRIG	N1123	Unidentfied charcoal	Inner rampart	2220±100	cal BC 400–150	cal BC 540–AD 10	
CRAIG PHADRIG	GX2441	Unidentfied charcoal	Below inner rampart	2130±100	cal BC 360–40	cal BC 400–AD 80	
CRAIG PHADRIG	N1118	Unidentfied charcoal	Fort interior	2030±100	cal BC 170–AD 110	cal BC 360–AD 220	
CRAIG PHADRIG	N1119	Unidentfied charcoal	Upper occupation layer	1540±85	cal AD 430–600	cal AD 360–660	
URQUHART	GU1768	Charcoal including *Betula sp.*	Cobbling UR221	1465±50	cal AD 570–650	cal AD 440–670; 530–670 (92.7%)	
URQUHART	GU1769	Unidentified charcoal	Cobbling UR262	1225±55	cal AD 700–890	cal AD 660–960	
URQUHART	GU1837	Unidentified charcoal	Cobbling UR263	1210±90	cal AD 680–950	cal AD 650–1000	

SITE	LABNO	MATERIAL	CONTEXT	RADIOCARBON AGE (BP)	CALIBRATED 1σ	CALIBRATED 2σ	$\delta^{13}C$%
URQUHART	GU1836	Unidentified charcoal	Cobbling, later reoccupation UR214/1	1085±100	cal AD 770–1040	cal AD 680–1170; 770–1170 (91%)	
URQUHART	GU1835	Unidentified charcoal	Cobbling, later reoccupation UR214/2	985±50	cal AD 990–1160	cal AD 980–1180 (94.5%)	
URQUHART	GU1924	Animal bone	Domestic waste overlying fort destruction UR259/1	860±50	cal AD 1050–1260	cal AD 1040–1270	
URQUHART	GU1925	Animal bone	Domestic waste overlying fort destruction UR259/2	845 ±60	cal AD 1150–1270	cal AD 1040–1280	
URQUHART	GU1926	Animal bone	Domestic waste overlying fort destruction UR259/3	805±50	cal AD 1210–1280	cal AD 1050–1290; 1150–1290 (93.4%)	
PORTKNOCKIE	GU1822	Unidentified charcoal	Old ground surface	1620±115	cal AD 260–570; 340–570 (65.2%)	cal AD 210–650	
PORTKNOCKIE	GU2092	Unidentified charcoal		1290±50	cal AD 660–780	cal AD 650–880	
PORTKNOCKIE	UB2149	Charcoal: *Quercus robur*	Rampart timber	1265±40	cal AD 670–800	cal AD 660–880	
PORTKNOCKIE	UB2150	Charcoal: *Quercus robur*	Rampart timber	1210±45	cal AD 710–890	cal AD 670–960	
PORTKNOCKIE	GU1820	Unidentified charcoal		1210±85	cal AD 680–950	cal AD 660–990	
PORTKNOCKIE	GU1816	Unidentified charcoal		1155±50	cal AD 770–980	cal AD 700–1000; 770-1000 (94.2%)	
PORTKNOCKIE	GU1817	Unidentified charcoal		1115±50	cal AD 880–1000	cal AD 770–1030; 820-1030 (91.5%)	
DUNDURN	GU1042	Charcoal: *Corylus avellana*	Phase 2A wattle floor	1510±60	cal AD 440–640	cal AD 430–650	
DUNDURN	GU1043	Unidentfied animal bone	Phase 1 below wattle floor	1435±65	cal AD 570–660	cal AD 430–780; 530–690 (87.2%)	
DUNDURN	HAR2519	Charcoal: *Corylus avellana*	Phase 2A wattle floor	1390±60	cal AD 590–760; 590–680 (64.9%)	cal AD 550–780	
DUNDURN	HAR2002	Charcoal: *Quercus robur*	Phase 2B rampart	1310±70	cal AD 650–780	cal AD 600–890	

SITE	LABNO	MATERIAL	CONTEXT	RADIOCARBON AGE (BP)	CALIBRATED 1σ	CALIBRATED 2σ	$\delta^{13}C$%
DUNDURN	HAR2001	Charcoal: *Corylus avellana*	Phase 2B rampart	1260±70	cal AD 670–870	cal AD 650–960; 650–900 (92.6%)	
DUNDURN	HAR2000	Charcoal: *Corylus avellana*	Phase 2B rampart	1190±70	cal AD 700–960	cal AD 670–1000	
RHYNIE	SUERC66389	Charcoal: *Betula sp.*	Outer ditch lower fill	1746±24	cal AD 250–350	cal AD 240–390	
RHYNIE	SUERC66388	Charcoal: *Corylus avellana*	Outer ditch lower fill	1726±29	cal AD 250–410	cal AD 250–410	
RHYNIE	SUERC66426	Charcoal: *Betula sp.*	Stone scoket fill	1726±29	cal AD 250–410	cal AD 250–410	
RHYNIE	SUERC35643	Charcoal: *Betula sp.*	Inner ditch	1655±30	cal AD 360–440 (66.9%)	cal AD 260–540	
RHYNIE	SUERC66398	Charcoal: *Salix sp.*	Palisade post	1647±29	cal AD 380–530	cal AD 260–540; 350–540 (93.3%)	
RHYNIE	SUERC66400	Charcoal: *Betula sp.*	Palisade base	1646±29	cal AD 380–540	cal AD 260–540; 350–540 (93.6%)	
RHYNIE	SUERC66431	Charcoal: *Betula sp.*	Palisade base	1640±29	cal AD 400–540	cal AD 360–540	
RHYNIE	SUERC45548	Charcoal: *Betula sp.*	Inner ditch upper fill	1623±29	cal AD 410–540	cal AD 400–550	
RHYNIE	SUERC66430	Charcoal: *Corylus avellana*	Stone scoket fill	1620±25	cal AD 410–540	cal AD 410–540	
RHYNIE	SUERC66394	Charcoal: *Betula sp.*	Palisade base	1601±29	cal AD 420–540	cal AD 410–550	
RHYNIE	SUERC35639	Charcoal: *Corylus avellana*	Palisade post	1600±30	cal AD 420–540	cal AD 410–550	
RHYNIE	SUERC35641	Charcoal: *Corylus avellana*	Building	1595±30	cal AD 430–540	cal AD 410–550	
RHYNIE	SUERC35647	Charcoal: *Betula sp.*	Sunken structure	1590±30	cal AD 430–540	cal AD 410–550	
RHYNIE	SUERC66425	Charcoal: *Betula sp.*	Palisade post	1585±29	cal AD 430–540	cal AD 420–550	
RHYNIE	SUERC35642	Charcoal: *Betula sp.*	Building	1580±30	cal AD 430–550	cal AD 420–560	
RHYNIE	SUERC35648	Charcoal: *Corylus avellana*	Building destruction layer	1580±30	cal AD 430–550	cal AD 420–560	
RHYNIE	SUERC35649	Charcoal: *Salix sp.*	Outer ditch destruction layer lower	1580±30	cal AD 430–550	cal AD 420–560	
RHYNIE	SUERC45545	Charcoal: *Corylus avellana*	Posthole possibly associated with plank structure	1577±29	cal AD 430–550	cal AD 420–560	
RHYNIE	SUERC66391	Charred seeds: cf *Hordeum vulgare*	Exterior structure floor layer	1572±29	cal AD 430–550	cal AD 420–570	

SITE	LABNO	MATERIAL	CONTEXT	RADIOCARBON AGE (BP)	CALIBRATED 1σ	CALIBRATED 2σ	$\delta^{13}C$%
RHYNIE	SUERC45553	Charcoal: *Betula sp.*	Outer ditch basal layer	1567±29	cal AD 430–550	cal AD 420–570	
RHYNIE	SUERC45538	Charcoal: *Betula sp.*	Rectuangular structure	1566±29	cal AD 430–550	cal AD 420–570	
RHYNIE	SUERC35637	Charcoal: *Betula sp.*	Outer ditch destruction layer upper	1565±30	cal AD 430–560	cal AD 420–570	
RHYNIE	SUERC66390	Charred seeds: cf *Hordeum vulgare*	Exterior structure floor layer	1563±29	cal AD 430–560	cal AD 430–570	
RHYNIE	SUERC45547	Charcoal: *Betula sp.*	Outer ditch upper fill	1559±29	cal AD 430–570	cal AD 420–580	
RHYNIE	SUERC66399	Charcoal: *Corylus avellana*	Palisade base	1558±29	cal AD 430–570	cal AD 420–580	
RHYNIE	SUERC45549	Charcoal: *Corylus avellana*	Rectuangular structure	1557±29	cal AD 430–570	cal AD 430–580	
RHYNIE	SUERC45544	Charcoal: *Corylus avellana*	Rectuangular structure	1554±29	cal AD 430–570	cal AD 430–580	
RHYNIE	SUERC66424	Charcoal: *Betula sp.*	Palisade base	1551±25	cal AD 440–570	cal AD 430–580	
RHYNIE	SUERC35640	Charcoal: *Betula sp.*	Palisade post	1550±30	cal AD 430–580	cal AD 430–590	
RHYNIE	SUERC45554	Charcoal: *Corylus avellana*	Inner ditch basal fill	1547±29	cal AD 440–580	cal AD 430–590	
RHYNIE	SUERC45539	Charcoal: *Betula sp.*	Rectuangular structure	1539±27	cal AD 440–590	cal AD 430–600	
RHYNIE	SUERC66432	Charcoal: *Salix sp.*	Palisade base	1535±29	cal AD 440–600	cal AD 430–600	
RHYNIE	SUERC45543	Charcoal: *Betula sp.*	Palisade post	1535±29	cal AD 440–600	cal AD 430–600	
RHYNIE	SUERC45546	Charcoal: *Corylus avellana*	Rectuangular structure	1529±25	cal AD 540–590	cal AD 430–610	

9.3.2 Unrefined enclosed settlements

The following figures are the models produced in OxCal 4.4 for the enclosed settlements dating to the 1st millennium AD. These include all radiocarbon dates, and not have been refined as in Chapter 5; where dates from uncertain contexts/with wide error margins were removed.

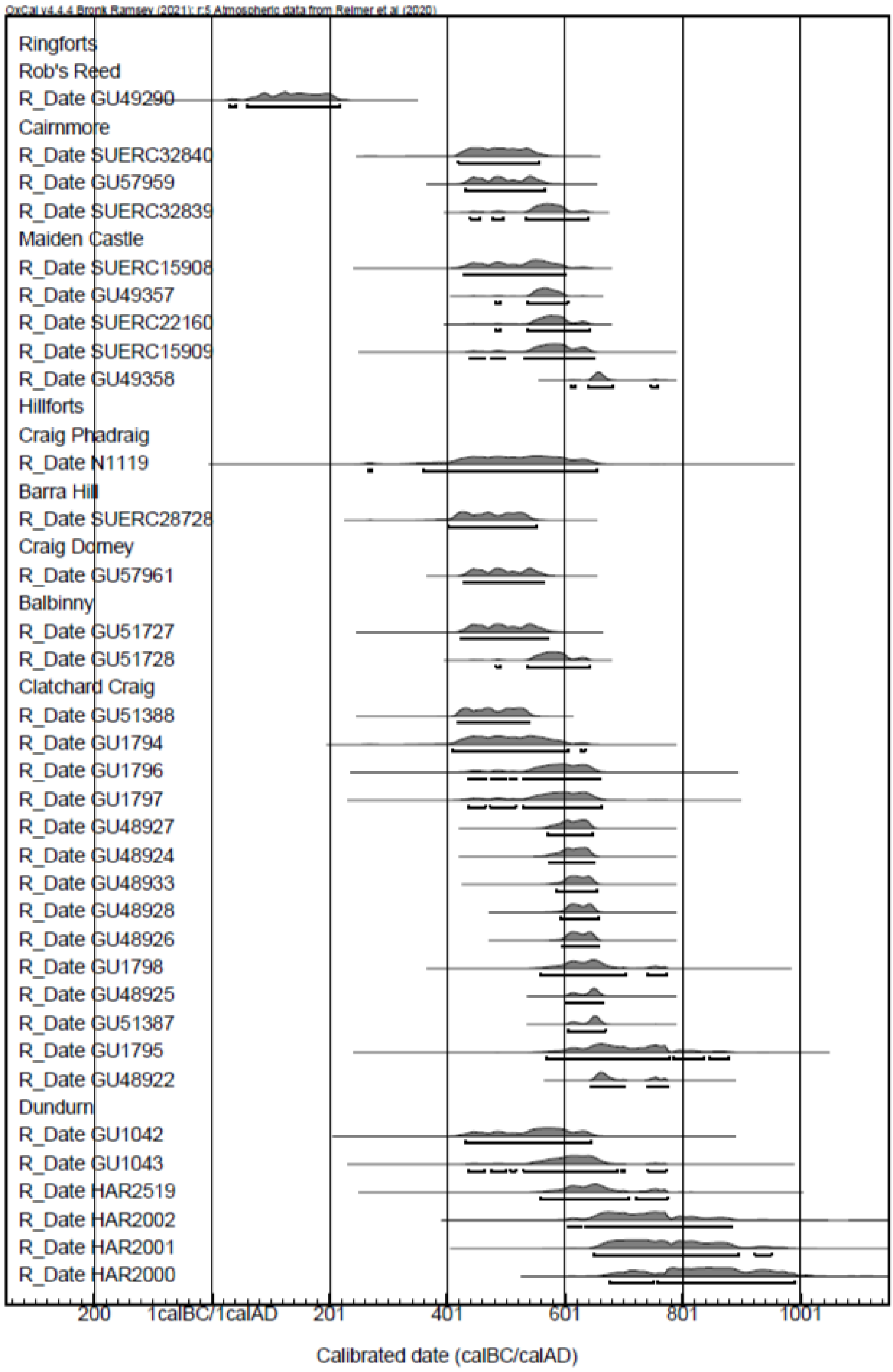

Figure 13: Radiocarbon dates for enclosed settlements part 1; ringforts and hillforts. Produced by author in OxCal 4.4.

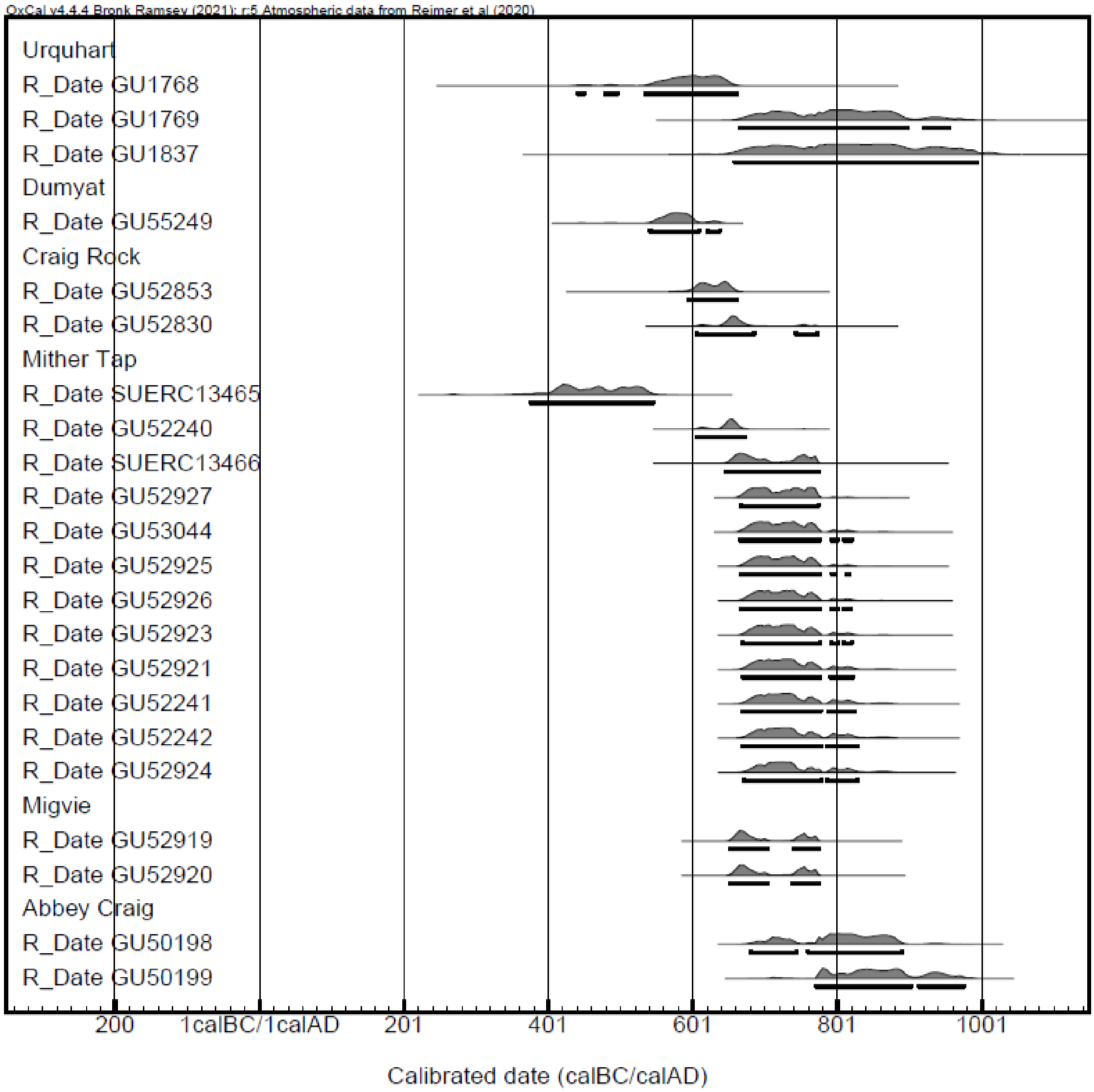

Figure 14: Radiocarbon dates for enclosed settlements part 2; hillforts continued. Produced by author in OxCal 4.4.

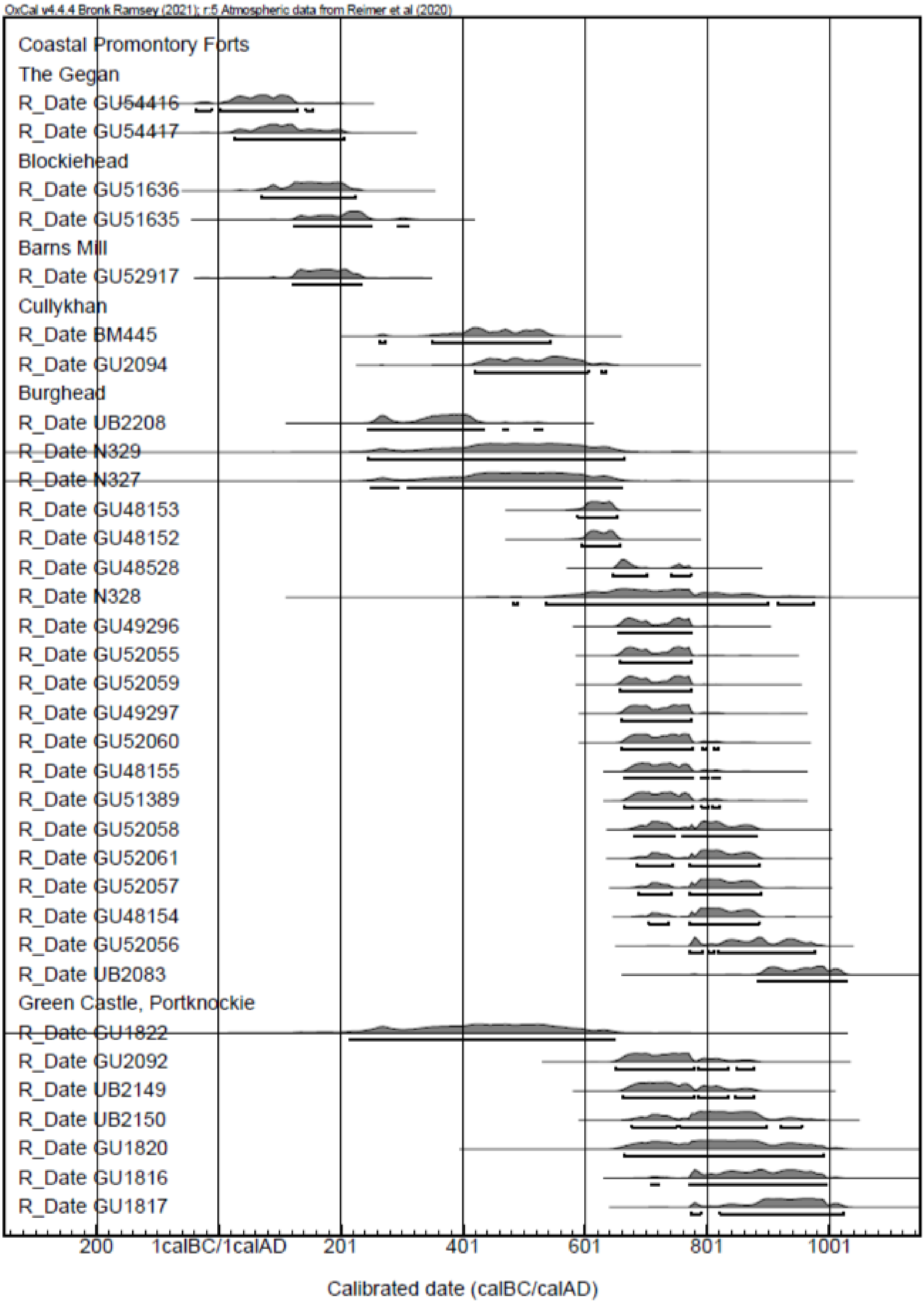

Figure 15: Radiocarbon dates for enclosed settlements part 3; coastal promontory forts. Produced by author in OxCal 4.4.

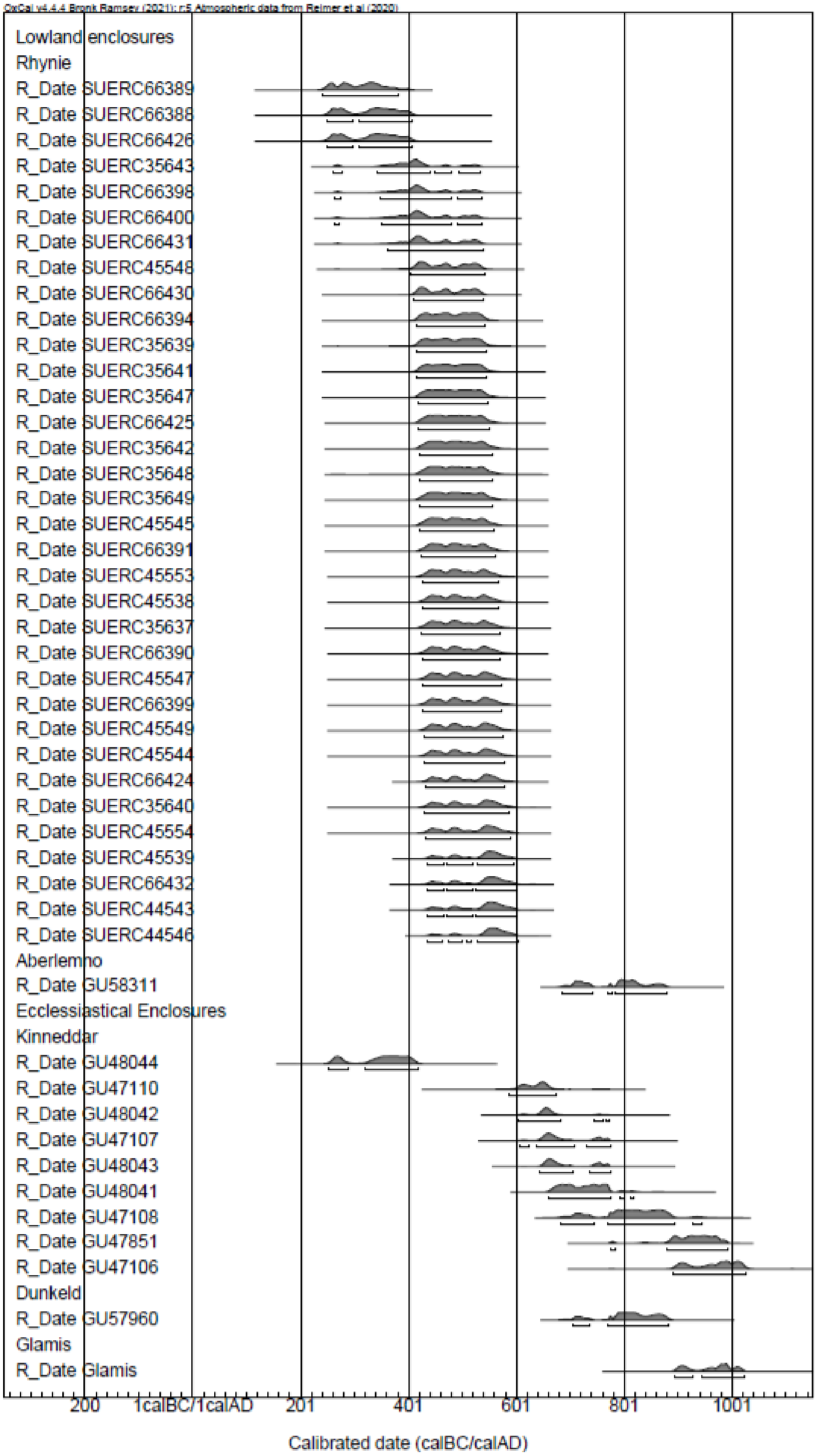

Figure 16: Radiocarbon dates for enclosed settlements part 4; lowland enclosures and ecclessiastical enclosures. Produced by author in OxCal 4.4.