REFRESH OF THE RESEARCH AGENDA FOR WALES: PALAEOENVIRONMENTS

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Introduction

Environmental archaeology plays an important role in understanding the environment in which people lived in the past, their lifestyles and how they responded to environmental change. A substantial amount of work has been undertaken in the last five years, adding to the palaeoenvironmental record for Wales from the Palaeolithic to modern times. Particularly noticeable is the important contribution of environmental reports arising from large-scale developer-driven projects, notably pipeline and road improvement projects and particularly the Milford Haven-Tirley (Gloucestershire) gas pipeline. Another notable development is the increasing number of studies involving stable isotope analyses. The following review is based on published reports and some unpublished reports, including some assessment reports, since 2010 and the evidence is considered under the themes and questions identified previously.

Environmental Context and Landscape Change

- How was the human presence in Wales during the Palaeolithic related to environmental conditions?

  Several recent excavations have provided further environmental evidence relating to the Palaeolithic period, namely from Pleistocene cave deposits with or without archaeological evidence associated. For example, a faunal assemblage, including woolly rhinoceros and spotted hyaena, recovered from Cathole Cave suggested use of the cave as an animal den during the mid-Devensian (Walker *et al* 2014). Analysis of the microfauna and sedimentological analysis indicated the environmental changes from the mid-Devensian through to the Late Glacial and Holocene. In addition an animal bone assemblage, characteristic with the cold period 65-10,000 years ago and consistent with the archaeological evidence, was also obtained from Ffynnon Beuno Cave (Conneller and Dinnis 2012). Further Pleistocene faunal

remains were also recovered during recent excavations at Foxhole Cave and ranged in date from approximately 33,500 Cal BC to the Late Glacial and early Holocene and none showed evidence of human modification (Schulting *et al* 2013). Soil micromorphology of a column of Late Glacial sediments, as well as showing features of ice lensing, showed the presence of microscopic charcoal, although the significance of this is unclear.

Other recent analyses from cave excavations that have contributed to an understanding of the palaeoenvironmental conditions during the Pleistocene have included studies of animal bone (Ingrem 2009, 2014) and bird bone (A. Eastham pers. comm.) from Little Hoyle and Hoyle's Mouth. New dating using ultrafiltration of faunal remains from Hoyle's Mouth and Little Hoyle Caves has also been undertaken (E. Walker pers.commm.). Another investigation included a re-examination of faunal material, as well as artefacts, from earlier collections from Cae Gwyn and Fynonnon Beuno caves and radiocarbon dating to determine the chronologies of the use of the caves by humans and carnivores and allow comparison with the faunal assemblages from Pontnewydd and Paviland (Aldhouse-Green *et al* 2015).

Also of note is the publication of the major excavation at Pontnewydd (Aldhouse-Green *et al* 2012) in which work by palaeontologists, stratigraphers, sedimentologists, dating specialists and isotope analysts has helped to provide the environmental context of the cave. In addition the evidence from this site and many others in Wales have made a significant contribution in recent publications resulting from the Ancient Human Occupation of Britain Project (e.g. Ashton *et al* 2011, Dinnis and Stringer 2014).

There has also been significant progress in the investigation of Quaternary submerged prehistory around the coastline of the British Isles and current evidence for submerged landscapes around the coast of Wales dates to the Late Pleistocene and Holocene (Fitch *et al* 2011, Wessex Archaeology 2013, Bicket and Tizzard 2015). It is considered there is potential for Middle Palaeolithic Neanderthal and more recent modern humans activity in the submerged landscapes off the coast of North Wales and in

the area of Liverpool Bay (Wessex Archaeology 2013, Bicket and Tizzard 2015).

A study relevant to the question of occupation at the end of the Palaeolithic period is an investigation into climate change in south Wales during the period 15,000-8,000 BP currently being undertaken as a PhD at Swansea University (see Climate Change below).

- How did the availability of resources influence Mesolithic occupation?

There has been an increasing amount of evidence emerging for environmental exploitation within Wales during the Mesolithic. Much of the evidence for the nature of the resources available and for their exploitation has come from upland pollen studies, such as Waun-Fignen-Felen (Smith and Cloutman 1988), and intertidal peat sites, notably Goldcliff (Bell 2007) in the Severn Estuary. Further pollen evidence, including microscopic charcoal evidence, suggesting the possible exploitation of upland environments during the Mesolithic has been obtained from, for example, Banc Wernwgan, Mynydd Du (Caseldine 2013a) and Graig Fawr (Grant 2011) in south Wales and Waun Llanfair (Caseldine *et al* forthcominga), Clogwyngarreg (Grant 2012a) and Ffridd y Bwlch (Grant 2012b) in north Wales.

In the intertidal zone, recent pollen studies covering the period of the Mesolithic-Neolithic transition at Lydstep have indicated the environmental conditions around the time of the 'Lydstep pig' and associated lithics, and the more recently discovered footprint tracks (Murphy *et al* 2014). In addition it is also now widely recognised that early Holocene archaeology is not confined to the inter-tidal zone and surveys have been undertaken to identify underwater palaeolandscapes (Fitch & Gaffney 2011).

Another area where there has been significant progress recently is in the investigation of shell middens, namely at two rock shelters, Garreg Hylldrem, Porthmadog (Robinson 2012) and Snail Cave, Great Orme (Smith and Walker 2014), where the survival of marine molluscs has provided evidence for seasonal exploitation of the marine zone during the Mesolithic. The conditions also favoured the

preservation of bone and, for example, at Snail Cave as well as shellfish gathering there was some evidence to suggest wildfowling, while crab and roe deer remains indicated other elements of the diet. Archaeobotanical evidence was also recovered from Snail Cave (McKenna 2014) and Pentrwyn at Great Orme (McKenna 2015), notably the ubiquitous hazelnut, while possible evidence for the exploitation of hazel woodland in south Wales was suggested by hazelnut, dated to the early Mesolithic, from a site associated with the A477 St Clears to Red Roses road improvement scheme in Carmarthenshire (Cobain 2014), from hazelnut from sites associated with the South Wales Gas Pipeline, including hazelnut dated to the early Mesolithic from a site near Brecon (Rackham 2014a) and later Mesolithic from a site near Cwmifor (Rackham 2014b), and the presence of hazelnuts at a Mesolithic site at Great Nash, Pembrokeshire (Griffiths 2016a).
Stable isotope analysis of human bone reveals information about diet and hence the environments exploited and there have been a number of studies in the past relating to the Mesolithic and Neolithic periods. Radiocarbon dating and stable isotope analysis of human bone recovered during recent excavations at Foxhole Cave, Gower, dating to the Late Mesolithic and Neolithic has demonstrated a marked difference in diet between the two periods (Schulting *et al* 2013). Marine foods were found to contribute around half of the protein for the Mesolithic individuals but made little or no contribution to the diet of the Neolithic individuals. This is contrary to previous results from the site.

- What were the environmental conditions in the immediate area and surrounding region of Neolithic and Bronze Age funerary and ritual monuments?

  Several recent pollen diagrams have provided information about the environmental context of Neolithic and Bronze Age funerary and ritual monuments. These include publication of pollen investigations, such as Craig y Dullfan and Banc Wernwgan (Caseldine 2013) and Waun Llanfair (Caseldine *et al* forthcoming a), undertaken as part of the Funerary and Ritual Project, as well as other pollen investigations (e.g. Caseldine *et al* 2014a, Grant 2011, 2012a,b , Mighall *et al* 2012, Mighall 2013, Woodbridge *et al* 2012) which also cover this time period. The studies, as well as indicating the nature of land use, also suggest possible land

management activity, notably the possible use of fire as a management tool during the Bronze Age.

Complementing pollen studies are charcoal analyses which have provided additional information about the woodland available for exploitation, or at least what was selected for use, for example, the analysis of charcoal from cremation pyres from funerary and ritual sites (e.g. Pwllheli to Blaenau Ffestiniog Pipeline (Challinor *et al* 2013, Kenney *et al* 2014), Fan Foel (Caseldine and Griffiths 2013a), Pant y Butler (Caseldine and Griffiths 2013b), Llanelwedd Rocks (Caseldine *et al* 2013a), Cefn Cwmwd (Gale 2012).

There have also been a number of charcoal analyses in recent years from burnt mound sites, viewed by some as possibly associated with ritual activity though a number of other reasons for their construction have been put forward and their function is still not fully understood. Sites include the Milford Haven to Brecon Pipeline (Hart *et al* 2014), as well as the Pwhelli to Blaenau Ffestiniog Pipeline (Kenney *et al* 2014) and other sites such as Robeston Wathen (Challinor 2010a, Schlee 2013) and Nant Farm (Caseldine *et al* forthcoming b), Waun Llanfair (Caseldine *et al* forthcoming a). Charcoal analyses again provide evidence of woodland composition and exploitation practices and complement pollen evidence, e.g. Pentrefelin (Kenney *et al* 2014), Nant Farm (Smith *et al* forthcoming b)and Waun Llanfair (Caseldine *et al* forthcoming a).

- Is there evidence of continuity of land-use and in the types of crops grown from the Romano-British to the early Medieval period?

Pollen evidence is especially useful in looking for evidence of continuity of land use and there have been a number of recent studies that encompass this period. Particularly informative is the landscape and environmental study undertaken by Tudur Davies (2015) which focuses on the early medieval period in the Llyn Tegid (Bala Lake) area and also includes a review of the pollen evidence for this period. In addition there have been a number of other recent pollen studies that cover this time period, mainly upland sites (Caseldine 2013, Caseldine *et al* forthcoming a, Grant 2011,

Grant 2012a, 2012b, Woodbridge *et al* 2012, Mighall 2013, Mighall *et al* 2012), although there have been a few pollen investigations in lowland areas, namely at Glan-Rhŷd in west Wales (Rackham 2014c), Langstone (Nayling *et al* 2011) and at Wentwood (Brown 2013a) in Gwent, as well as preliminary pollen work in the eastern Vale of Glamorgan (Davies *et al* 2015). The latter, which included a number of pollen sites, indicated the potential for a detailed landscape study to be made covering the Romano-British/ early Medieval period. The study area includes Dinas Powys and Caerau hill-forts as well as the monastery at Llandough.

As for prehistoric periods, charcoal studies provide information about the nature of woodland in an area, or at least the woodland exploited, including possible evidence of coppicing as well as the species of tree (e.g. South Hook (Challinor 2010b), West Angle (Caseldine and Griffiths 2011b), Merryborough Farm, Wiston (Rackham 2013a).

Radiocarbon dating has played an important role in the recognition of plant assemblages dating to the early medieval period (e.g. Glanfred (Carruthers 2013a), Priory Farm, Caerleon (Caseldine and Griffiths 2011a), Cromlech Farm (Caseldine and Griffiths 2013c), Carrog (Caseldine *et al* 2014b)) and there have been a number of recent investigations dating to this period. Recent studies of charred plant assemblages dating to the early medieval period, for example at South Hook, Herbranston (Carruthers 2010a), Glanfred, Llandre (Carruthers 2013a), West Angle (Caseldine and Griffiths 2011b), Porth Clew (Caseldine and Griffiths 2012c), Cromlech Farm (Caseldine and Griffiths 2013c), Carrog (Caseldine *et al* 2014b) Ysgol yr Hendre (McKenna 2013), Priory Field, Caerleon (Caseldine and Griffiths 2011a) and sites associated with the Milford Haven to Brecon gas pipeline (e.g. Rackham 2013b, 2014d,e), have added considerable support to the view that there was a significant change in the cereals cultivated from the Romano-British period to the early medieval period. It is evident that oats, barley and free-threshing wheat, especially oats, became much more important during the early medieval period and that spelt wheat, dominant during the Roman period, was replaced by free-threshing wheat. In particular, the increased importance of oat may reflect changes in the environment and society. An assessment of samples from the A477 St Clears to Red Roses road improvement scheme in

Carmarthenshire has indicated there is further archaeobotanical evidence dating to the early medieval, Romano-British and Medieval periods (Cobain 2014).

Whereas there has been a continued increase in the evidence from plant macrofossils for cereal cultivation, unfortunately the same cannot be said for livestock farming, and faunal assemblages remain scarce, although there have been faunal remains recovered from, for example, post-Roman features at Priory Fields, Caerleon (Andrews *et al* 2011).

Supplementing the botanical and faunal studies which have provided information about land use and diet, is the stable isotope analysis of skeletons which has been undertaken on a number of early medieval cemeteries, including Brownslade, West Angle, Porth Clew, St Patrick's Chapel, Atlantic Trading Estate and Llandough in south Wales and the Viking Age settlement at Llanbedrgoch, Anglesey (Hemer 2011; Hemer *et al* 2013; Hemer *et al* in press, Hemer *et al* forthcoming). These studies have given some indication of the importance of terrestrial foodstuffs as opposed to marine sources of food in the diet, as well as providing information about population mobility and trade. Stable isotope analysis of skeletons from Brownslade, West Angle, Porth Clew and St Patrick's Chapel, Pembrokeshire, have suggested a terrestrial based diet and that marine protein was not a significant contributor to the diet (Hemer 2011, 186–7; Hemer *et al.* in press), whilst isotope analysis of early medieval, medieval and post-medieval individuals from Lesser Garth Cave, Cardiff, Cathole Cave, Gower has also suggested a terrestrial diet with animal protein (meat/dairy) making a significant contribution to the diets of all the individuals (Madgwick *et al* 2016). An osteological assessment of human remains from an early medieval cemetery, found as a result of the Llangefni Link Road, suggests there is potential for isotope analysis and aDNA analysis and would make a particularly important contribution to early medieval studies in north west Wales (Rusu 2016).

As well as diet, stable isotope analysis may be an indicator of agricultural practices and at Brownslade high strontium values may indicate the consumption of seaweed or the use of seaweed as a fertiliser (Hemer 2011, Hemer *et al* in press). At Brownslade archaeobotanical evidence suggested the use of seaweed from the

Iron Age through to possibly the post-medieval period (Carruthers 2011).

- Is there similar evidence across the Iron Age/Romano-British boundary?

Again a number of recent pollen records cover this period and the majority of them are from the uplands (e.g. Brown 2013, Caseldine 2013, Caseldine *et al* (forthcoming), Grant 2011, Grant 2012a, 2012b, Woodbridge *et al* 2012, Mighall 2013, Mighall *et al* 2012), including pollen evidence from ditches associated with the Caer Gai to Tomen y Mur Roman road (Scaife and Rackham 2014).

Sites spanning the Late Iron Age to Romano-British period and in some instances extending into the early medieval period include Ffynonwen (Caseldine and Griffiths 2012a), Troedyrhiw (Caseldine and Griffiths 2013d) and Porth y Rhaw (Caseldine and Griffiths 2010a) in southwest Wales and Cefn Du and Cefn Cwmwd (Ciaraldi 2012a) in north Wales as well as later Iron Age evidence from Brownslade Barrow (Carruthers 2011), Moel-y-Gaer Hillfort (Caseldine and Griffiths 2013e), Caer Seion (Caseldine and Griffiths 2012b), Smithfield Livestock Market (O'Brien 2014) and from the Pwllheli to Blaenau Ffestiniog Pipeline (Challinor *et al* 2013, Kenney *et al* 2014). Much of the evidence is quite limited though a large concentration of cereal remains were identified in a Later Iron Age pit in the Pwllheli to Blaenau Ffestiniog Pipeline (Challinor *et al* 2013, Kenney *et al* 2014). Archaeobotanical evidence from excavations at Caerau Hillfort will also provide an important contribution to the dataset (Wessex Archaeology 2013; Davis and Sharples 2013, 2014). At Parc Cybi assessment of the archaeobotanical evidence indicates that much of the cereal evidence dates to the Roman period (Kenney *et al* 2011). The archaeobotanical evidence from these sites is important for assessing the degree of continuity and contrast across the Roman period transition. Additional Roman evidence is discussed further below.

- What were the environmental conditions associated with wetland sites?

Recent environmental work on wetland sites has largely been confined to coastal sites including Redwick and Peterstone and other sites in the Severn Estuary (Bell 2013), Kenfig (Bennett *et al* 2010), Oystermouth (Caseldine 2011a), Lydstep (Murphy *et al* 2014) and Borth (N.Nayling & M. Bates pers.comm.) and has provided information about the environmental conditions contemporary with archaeological sites as well as changing environmental conditions in response to sea level change. However there have also been some investigations away from the inter-tidal area including palaeoenvironmental investigations at Langstone (Nayling *et al* 2011) in Gwent where a hoard dating to the Late Iron Age/Early Roman period was discovered. In addition there are environmental analyses, currently ongoing, of peat deposits associated with a timber from Maerdy, Rhondda, dated to the Late Mesolithic/Early Neolithic and with marks interpreted as decorative carving (Grant 2013, Jones 2014). Medieval timber, including a possible timber causeway, was also recovered from alluvial deposits during investigations associated with the Pwhelli-Blaenau Ffestiniog pipeline route but there was limited associated environmental evidence (Kenney *et al* 2014).

- Is there is any discernible difference in the environmental and biological evidence for land use across the interface between Welsh and English dominated parts of Wales and the marches in the early medieval and medieval periods?

  The increasing number of studies dating to the early medieval and medieval periods contribute to this.

- Is there evidence for the exploitation of lakes during prehistoric and later times?

- **The development of agriculture and changing agricultural practices**
- When and where did cereal cultivation and animal husbandry begin during the Mesolithic/Neolithic transition in Wales?

  There have been several more grain assemblages from sites dated to the early Neolithic but very few where cereal grain itself has been directly dated, for example Penywyrlod (W.J. Britnell pers.

comm.) There are several sites associated with the Milford Haven–Brecon gas pipeline (e.g. Pannett 2012, Rackham 2013c, 2013d, 2014b,2014f, 2014g 2014h) which have also produced early Neolithic cereal as well as other sites including Fan (Foster *et al* 2013), Carrog (Caseldine *et al* 2014b) and Borras Quarry (Archaeological Services Durham University 2010, 2013). Direct dating of cereal grains in Early Neolithic contexts should be a key priority to assess the timing of the introduction of cereals and to account for problems of intrusive (later) cereal grains in Neolithic sites.

The lack of survival of animal bone on prehistoric sites in Wales continues to hamper the identification of when and where animal husbandry began in Wales. For example, only burnt bone, with just one fragment possibly identifiable to red deer, was recovered from Early Neolithic pits at Carrog (Madgwick 2014), while bone from an early-middle Neolithic site near Lower Scoveston, Milford Haven could only be assigned to large and medium-sized mammals (Rackham 2014g).

As previously mentioned, further radiocarbon dating and stable isotope analysis of human skeletons has been undertaken on Mesolithic and Neolithic human remains, namely from Foxhole Cave, Gower, to examine dietary changes across this critical transition and has demonstrated a distinct shift from marine foods making up a significant element of the Mesolithic diet to an almost totally terrestrial diet in the Neolithic (Schulting *et al* 2013).

- What was the nature of farming activity during the Neolithic and earlier Bronze Age in Wales?

  Pollen records from a number of recent investigations (Brown *et al* 2013 Caseldine 2013, Caseldine *et al* 2013b Caseldine *et al* forthcoming, Grant 2011, 2012a,b , Mighall *et al* 2012, Mighall 2013, Woodbridge *et al* 2012,) indicate farming activity during the Neolithic and Bronze Age and some of the records include fungal spore evidence indicative of dung, supporting the pollen evidence for pastoral activity.

  Once more the lack of survival of animal bone hinders the investigation of animal farming during this period with only limited

evidence from dry land sites, for example at the early-middle Neolithic site near Lower Scoveston, Milford Haven (Rackham 2014h), and from Late Neolithic pits at sites near Steynton, Milford Haven (Rackham 2014i) and Westfields, Rosemarket (Rackham 2013e). The major exception is evidence from wetland sites such as Redwick and Peterstone where animal bone evidence is also supplemented by footprint tracks and suggests a form of seasonal-transhumance activity during the Bronze Age (Bell 2013).

In contrast archaeobotanical evidence has been recovered from a range of Neolithic and Earlier Bronze Age sites including funerary and ritual, settlement and burnt mound sites (e.g Carrog (Caseldine *et al* 2014b), the Milford Haven to Aberdulais/Brecon Pipeline (Pannett 2012, Rackham and Challinor 2014), Borras Quarry (Archaeological Services Durham University 2010, 2013), Ysgol yr Hendre (McKenna 2013), Llangefni to Penymynydd Pipeline (McKenna 2010), Pwllheli to Blaenau Ffestiniog Pipeline (Kenney *et al* 2014, Challinor *et al* 2013), Pant y Butler (Caseldine and Griffiths 2013b), Llanelwedd Rocks (Caseldine *et al* 2013a), South Hook (Carruthers 2011), Penrhosgarnedd (Carruthers 2013b), St George's Quarry (Wood 2009, Carrot 2013) and the A477 St Clears to Red Roses road scheme in Carmarthensire (Cobain 2014).

Archaeobotanical evidence from Early Neolithic rectangular structures and Neolithic pit clusters at Llanfaethlu (Rees and Jones 2015) and an Early Neolithic rectangular structure and several pit clusters at Parc Cybi (Kenney *et al* 2011) as well as from, for example, a site near Cwmifor, Carmarthenshire, (Rackham 2014b), is particularly important, considering the rarity of archaeobotanical evidence associated with Early Neolithic rectangular structures in Britain. Although many of the sites have produced only limited evidence for cereals, and hence crop husbandry practices, they do add to the record of cereal growing and the types of cereal grown. Evidence from early and later Neolithic pits may suggest changes in economy and lifestyle during the Neolithic, continuing into the early Bronze Age (Pannett 2012).

Following on from a recommendation in the last Palaeoenvironmental Review that stable isotope analysis on cereal grain should be undertaken, a pilot study using stable isotope analysis on cereal grains on Neolithic sites in Wales to investigate early farming practice has been undertaken by Edward Treasure (Durham University). Stable isotope studies on plant remains is also important for establishing a baseline for palaeodietary studies.

- When did changes in agricultural practices occur and what was the nature of these changes?

This has already been touched upon under 'Environmental Context and Landscape Change', particularly in relation to the Late Iron Age/Roman and Roman Early/Medieval boundaries (see above). There is also further discussion of Roman evidence below but consideration also needs to be given to the Later Bronze Age/ Early Iron Age and the medieval and post medieval periods.

The Later Bronze Age/ Earlier Iron Age is one period where there has been only limited understanding of agricultural practices due to a scarcity of excavated sites with associated archaeobotanical evidence. There has, however, been some earlier Iron Age archaeobotanical evidence recovered from Carrog (Caseldine *et al* 2014b), Pwllheli to Blaenau Ffestiniog Pipeline sites (Challinor *et al* 2013, Kenney *et al* 2014) and Brownslade Barrow (Carruthers 2011). At Brownslade Barrow, windblown sand sealed an arable soil with evidence for plough marks and containing charred grain dating to the Iron Age, and the occurrence of seaweed possibly indicated its use as a fertiliser (Carruthers 2011). Of particular note is the relatively large cereal assemblage from Llanmelin hillfort (Carruthers 2016a) which adds significantly to the Iron Age archaeobotanical record in Wales.

The lack of animal bone from Iron Age sites, with the exception of sites such as Goldcliff, means that the assemblage from the large midden dating to the Early Iron Age at Llanmaes (Madgwick and Mulville 2015) is especially important. Other assemblages, for example Caerau Hillfort (Jones 2013, Madgwick and Hodkinson 2014) and Pen-y-Dinas hillfort (Smith 2012, Jacques 2012),

although restricted, also make a welcome contribution to the record of Iron Age animal husbandry practices in Wales and elsewhere in Iron Age Britain. The faunal assemblage from Caerau suggests a clear change in animal husbandry from a focus on cattle during the Iron Age to caprines and cattle during the Roman period (Madgwick and Hodkinson 2014).

Medieval cereal assemblages have been recovered from several sites including defended enclosures near St Mary's Church (Smith *et al* 2012) and at Hen Gastell (McKenna 2016, Kenney 2016), St Ishmael (Caseldine and Griffiths 2015), Porth Clew (Caseldine and Griffiths 2012c), South Hook (Carruthers 2010a), Deanery Yard, Bangor (Smith 2015), sites associated with the Pwhelli to Blaenau Ffestiniog pipeline (Challinor *et al* 2013, Kenney *et al* 2014) and sites associated with the Milford Haven-Brecon pipeline (e.g. Rackham 2013a, 2014i). Large quantities of cereal remains have been recovered from medieval features at Four Crosses, making a valuable contribution to the investigation of agriculture for this period (ASUD 2012) and archaeobotanical evidence from Nevern Castle, Pembrokeshire, will also add to the medieval archaeobotanical dataset (Caple pers. comm). Evidence dating to the post-medieval period is scarce but cereal grain was recovered from a shell midden, possibly dating to the post-medieval period, at Brownslade (Carruthers 2011) and a post-medieval farm at Penygraig, Llanelwedd (Caseldine *et al* 2013a) as well as urban sites (see below).

As well as the recent evidence for cereal growing during the medieval period, there have also been several studies which add to the record for animal husbandry. Unlike most medieval rural sites in Wales bone preservation, including fish bone, was good at the deserted medieval settlement at St Ishmael (Browning 2015). Although the assemblage was not large, it did demonstrate that both land and marine resources were exploited with cattle, sheep/goat, pig and various fish represented. A small medieval animal bone assemblage was also recovered from the excavations at Porth Clew (Higbee 2010) and was dominated by livestock species, mainly cattle and sheep/goat though pig was also present. Cattle and pig were also represented in a small assemblage probably dating to the 11th-12th century recovered from the enclosure at St Mary's Church (Smith *et al* 2012) and in a poorly

preserved burnt animal bone assemblage of similar date from the enclosure at Hen Gastell (Bermingham 2016, Kenney 2016). Animal bone dating from the 12th century through to the post-medieval period was also recovered during excavations in the Deanery yard, Bangor and showed some variation through time (Smith 2015, Smith *et al* 2013). Fish bone and marine molluscs were also recovered.

Stable isotope analysis of animal bone can also indicate whether animals were from the local farms or from elsewhere. For example, stable isotope analysis has contributed to an understanding of where animal provisions came from at Dryslwyn Castle where isotopic analysis of pigs has indicated that they might have been acquired from outside the local area during the initial phase of English occupation (Millard *et al* 2011).

Multi-period sites have the potential to provide insights into agricultural change over long time periods from the Neolithic to Medieval period such as at Parc Cybi (Kenney *et al* 2011) and Four Crosses (Jones and Grant 2011). Equally environmental evidence from recent pipeline and road development projects have added greatly to the investigation of agricultural change.

A synthesis of available archaeobotanical evidence from prehistoric sites in Wales has been undertaken as part of a research Master's degree at Durham University (E. Treasure pers. comm.). Whilst van der Veen *et al* (2008; 2013) have reviewed the state of archaeobotanical research in Roman and medieval Britain, highlighting that there is currently a paucity of evidence from Wales in comparison to other regions.

One area of study concerned with early agriculture in Wales which has also been the subject of a palaeoenvironmental investigation is an investigation of prehistoric field systems in Gwynedd (Smith *et al* forthcomingb).

- What was the economy of medieval and post-medieval farms in the uplands and to what extent did climatic and other environmental changes contribute to farm abandonment and changes of agricultural regime?

Several recent pollen records have demonstrated the evidence for land use activity during the medieval and post medieval periods (e.g. Caseldine 2013a, Caseldine *et al* (forthcoming), Davies 2015, Grant 2011, Grant 2012a, 2012b, Mighall 2013, Mighall *et al* 2012, Scaife *et al* 2014, Woodbridge *et al* 2012) but in general there is comparatively little palaeoenvironmental evidence from medieval and post-medieval farmsteads in the Welsh uplands. Therefore the cereal and charcoal evidence (Caseldine *et al* 2013a) from a corn-drying kiln and bread oven at Penygraig, Llanelwedd makes a useful contribution. Unfortunately the animal bone evidence (O'Brien 2013) from the site was very limited.

- What is the relationship between the Roman army and native populations in terms of agricultural supply, particularly at such sites as Caerleon?

  Rather more animal bone evidence is available from Roman sites than prehistoric sites, although generally not from rural sites, with the exception of limestone areas. Hence in a recent study of the zooarchaeological evidence for Roman Caerleon and Chester and their hinterlands it was concluded that the reasons for the changes in diet and the timing of the changes, identified in both the fortresses and their surrounding areas, were not fully understood based on the current relatively limited evidence (Allsop 2013).

  Recent investigations at Caerleon have included studies of animal bone (Andrews *et al* 2011), including strontium isotope analysis, and charred plant remains (Caseldine and Griffiths 2011) from Priory Field, Caerleon and charred plant remains (Jones 2015) from the cemetery at Ultra Pontem, Caerleon and have provided further evidence for the relationship between Caerleon and the surrounding area. In addition, although the assemblage was relatively small, the assessment of faunal remains from Hartridge Farm, Newport (Castellano *et al* 2015) suggests that it has the potential to make a valuable contribution to animal husbandry studies in south east Wales and especially to understanding the relationship between Caerleon and farms in the surrounding area.

  Environmental evidence from the Roman settlement of Tai Cochion (Hopewell 2016a) on Anglesey has also contributed to an

understanding of the rural economy on Anglesey and the relationship with *Segontium*. Equally the evidence from Roman *vici* such as Hindwell Roman *vicus* (Caseldine and Griffiths 2012) is of interest in understanding the relationship between the Roman army and the native population. Also, in addition to the recent evidence relating to the agricultural economy from Late Iron Age and Romano-British rural sites discussed above, charred cereal evidence has also been published from the Romano-British settlement at Plas Coch, Wrexham (Caseldine and Griffiths 2011), Jamesford Roman coin hoard and enclosure site, where there were also traces of ploughing (Hankinson *et al* 2012), a Roman lime-kin at Y Bryn, close to the Roman Bath-house at Tremadog, and smithing pits discovered on the route of the Porthmadog Bypass (Parry and Kenney 2013, McKenna 2013).

What was the relationship between Roman towns and the surrounding regions?

Although animal bone assemblages are generally poor or lacking on most Romano-British rural sites in Wales, there is an increasing amount of archaeobotanical evidence from late Iron Age/Romano-British sites rural sites which can contribute to our understanding of the relationship between Roman towns and the surrounding regions. For example recent investigations at Ffynnonwen (Caseldine and Griffiths 2012a) and Troedyrhiw (Caseldine and Griffiths 2013d) potentially add to our understanding of the relationship between Carmarthen and the surrounding region. Equally the faunal assemblage from Hartridge Farm, Newport (Castellano *et al* 2015) is of value in investigating the interaction between the Roman town of Caerwent and farms in the region as well as the fortress at Caerleon .

- What is the evidence for the development of horticulture in Wales?

Evidence for this remains limited, although, for example, the occurrence of legumes at Caerleon could represent either a field or garden crop (Jones 2015).

- What was the role of hunting, fishing and wildfowling in agricultural societies in Wales?

In general there is only limited evidence for the role of hunting, fishing and wildfowling in prehistoric agricultural societies in Wales because of poor bone survival, for example only one possible red deer fragment was recovered from an Early Neolithic pit at Carrog (Madgwick 2014). However there is some recent evidence from Peterstone in the Severn Estuary for the hunting of red and roe deer and for wildfowling, as well as possibly fishing, during the Bronze Age (Ingrem 2013). Wooden structures were possibly fish traps (Bell 2013), but the presence of fish bones could not be directly related to the structures.

Fish-weirs and traps off Sudbrook Point, Monmouthshire (Brown *et al*. 2010), dating from the late eighth century onwards also indicate fishing played a role in the economy, the animal bone evidence from the deserted medieval village at St Ishmael illustrates that the inhabitants, as well as being involved in farming, were also involved in fishing (Browning 2015). Apart from fishing, there is also evidence, for example, from the Roman settlement at Tai Cochion on Anglesey (Hopewell 2016) for the harvesting of marine shells and a shell midden, comprised largely of common cockle, discovered on the route of the Porthmadog Bypass demonstrates similar activity (Parry and Kenney 2013).

Animal bone is quite often more frequent on medieval sites and a recent synthesis of data has enabled a comparison of deer assemblages from high status medieval sites in south Wales and identified some differences (Maltby and Hambleton 2014). Red deer outnumbered roe deer at the Anglo-Norman sites of Laugharne, Loughor and Rumney and during the English phase at Dryslwyn whereas the opposite was true during the Welsh period at Dryslwyn, though whether this was attributable to differences in local availability was unclear.

Social organisation and belief systems

- What is the evidence for social organisation both at a site and a regional level?

  Evidence from most of the recent excavations will help to contribute to a better understanding of social organisation at a regional level in the long-term, while activities such as crop

processing and butchery activities indicate social organisation at a site level. For example, archaeobotanical evidence has demonstrated the evidence for crop processing at the early medieval settlement, iron smelting site and crop processing complex at South Hook (Carruthers 2010a). Similarly at the Roman settlement of Tai Cochion there is evidence for crop processing and where it was taking place (Caseldine *et al* 2016). In addition the evidence from Tai Cochion, along with evidence from other Romano-British sites on Anglesey (e.g. Ciaraldi 2012) and in Gwynedd, as well as from Segontium, contributes to a greater understanding of the social organisation of the region during the Roman period. Similarly, hillforts had complex relationships with their surrounding settlements and investigation of charred plant remains from, for example, Llanmelin hillfort (Carruthers 2016a) should contribute to a better understanding of social organisation during the Iron Age in south Wales in the future.

Unfortunately animal bone rarely survives on prehistoric sites in Wales, apart from in limited areas. Hence one study which is particularly valuable because it is a prehistoric site and demonstrates social organisation is Llanmaes. The faunal evidence from the Early Iron Age midden at Llanmaes suggests that feasts were a means of reaffirming inter-community relations and resource redistribution (Madgwick and Mulville 2015). The faunal assemblage from Llanmaes, dominated by pigs and in particular right forequarters, was considered to represent highly formalised, socially circumscribed practices, namely feasting rather than sacrificial offerings (Madgwick and Mulville 2015). Carbon and nitrogen stable isotope evidence suggested the pigs came from different areas with a variety of resources and from different social units. Strontium isotope analysis also suggested the pigs came from multiple regions.

An assessment of a modest sized Late Iron Age/Roman faunal assemblage from Hartridge Farm, Newport suggests the assemblage has the potential to explore social and economic relations with Caerleon and Caerwent (see above), as well providing information about processing and waste –management at the site (Castellano *et a*l 2015).

- What is the evidence for ritual activity and belief systems?

  Environmental evidence may be an indicator of ritual activity and several recent investigations provide some evidence to support this. Charred cereal remains are generally scarce on funerary and ritual sites but may represent food offerings, for example at cairns at Llanelwedd Rocks (Caseldine *et al* 2013a), Fan round barrow (Foster *et al* 2013), a cremation burial on the Pwhelli-Blaenau Festiniog route (Challinor et al 2013, Kenney *et al* 2014) and sites along the Milford Haven – Brecon pipeline route (Rackham 2013f, 2014d, i), although the plant remains possibly represented food waste incorporated in the funeral pyre. However, a relatively large number of charred cereal grains from a pit containing an early Bronze Age urn at South Hook suggested ritual deposition (Carruthers 2010). Similarly, cremated animal bone in the cremation burials at Llanelwedd Rocks (O'Brien 2013), Fan Foel, Mynydd Du (Coard 2013a), Pant y Butler (Keefe and Holst 2013)and Buttington Cross (Western 2014) may reflect funerary rituals associated with the cremations. Cremated animal bone from Pant y Butler included pig and at Buttington Cross possibly a new-born, medium-sized mammal.

  In keeping with evidence from earlier Bronze Age sites in Scotland, there is also pollen evidence from recently published excavations at Fan Foel (Caseldine and Griffiths 2013a), Pant y Butler (Caseldine 2013b) and Buttington Cross (Daffern 2014) where meadowsweet pollen has been identified associated with burials and interpreted as possibly reflecting ritual activity.

  The wood used to make the funeral pyres may also have had some ritual significance on Bronze Age sites. In general recent charcoal studies are consistent with earlier studies and suggest a preference for oak in funerary sites (e.g. Pwllheli to Blaenau Ffestiniog Pipeline (Challinor *et al* 2013, Kenney *et al* 2014), Fan Foel (Caseldine and Griffiths 2013a), Pant y Butler (Caseldine and Griffiths 2013b), Cefn Cwmwd (Gale 2012)), though this could simply reflect the qualities of the wood for burning and its availability rather than it having some ritual significance, or perhaps a combination of both.

  Evidence for the use of plant material at funerary sites has also been recovered from a Roman cremation cemetery at Caerleon

where the charred remains recovered from burial pits were possibly food offerings, although some of the remains may have found their way on to the pyre with the fuel (Jones 2015). Animal bone from the cremations may also represent a meal to accompany the dead or represent the remains of ritual feasting (Hamilton-Dyer 2015). Contrasting with the Bronze Age evidence, examination of charcoal from the funeral pyre indicated a wide range of species had been used (Gale 2015), suggesting there was not a particular preference or simply reflects the available woodland resources.

As well as evidence from funerary sites, plant and animal assemblages indicative of food waste from Neolithic pits may represent ritual deposition at the end of a period of occupancy of a site, for example at sites associated with the Milford Haven to Brecon pipeline (e.g. Rackham 2013e, 2014h). Additionally, as already mentioned, the faunal assemblage from Llanmaes suggested feasting and the midden itself could be seen as a ritually significant structure (Madgwick and Mulville 2015). The deposition of hoards is also associated with ritual activity and investigation of the environmental conditions existing at the site of the Langstone tankard and metalwork hoard during the Late Iron Age/Early Roman period suggested that the artefacts were ritual deposits in pools or marshy areas within a clearing (Nayling *et al* 2011).

Mining Activity and Industrialization

- What was the impact of metal-mining on the environment from the Bronze Age through to the medieval period?

The importance of the evidence from Wales for early metal-mining activity in the UK is widely acknowledged and further evidence for metal-mining dating from the Late Iron Age/Roman period through to the post medieval period has been obtained through the Metal Links Project/RCAHMW, namely palaeoecological and geochemical studies from Clogwyngarreg (Grant 2012) and the Plynlimon area (Mighall *et al* 2012, Mighall 2013.) At Clowyngarreg lead mining in the wider region is possibly suggested during the Roman period, with increased evidence for lead mining during the medieval period and an intensification of activity, notably copper mining, during the Industrial period. The Plynlimon studies have indicated a lead extraction industry in the wider region and possibly from more local sources during the Late Iron Age/Roman period. There is also evidence for lead mining during the post medieval period. The

palaeoenvironmental evidence, including pollen, geochemical and charcoal analyses, for lead mining and smelting and its impact on the environment from the Late Iron Age/Roman site at Erglodd, Llangynfelyn (Caseldine *et al* 2012) has also been published. In addition identification of charcoal from the copper smelting site at Pentrwyn, Great Orme has demonstrated the woodland trees exploited for fuel (McKenna 2015).

What was the impact of iron-working on the landscape from the Iron Age to Medieval times?

Combined pollen and dendrological charcoal analyses have demonstrated careful use and management of woodland at a 14th century bloomer, Llwyn Du, in Snowdonia (Crew and Mighall 2013), and indicated the potential for further studies. Analysis of the charcoal from early medieval iron smelting furnaces at South Hook demonstrated the fuel used and hence indicated the woodland resources available (Challinor 2010b). In addition charcoal analysis from a site at Canaston Wood, Llawhaden, thought to have been involved in the production of charcoal for industrial purposes during the medieval and post medieval periods, has demonstrated the woodland resources that were utilised (Rackham 2014h).

- What is the evidence for silver mining in Wales?

The geochemical evidence for early silver mining is still much slimmer than for other metals. Although geochemical analyses primarily suggest copper or lead mining in Wales, recent analyses from the prehistoric/Roman lead smelting site at Erglodd, Llangynfelyn suggested there was a slight possibility of silver production (Page *et al* 2012).

- What is the evidence for industrialisation and more recent pollution from agricultural activities and the significance of this in relation to conservation and upland management?

Several recent studies have demonstrated the evidence for industrialisation and pollution from agricultural activities. There are increased concentrations of lithogenic elements in the upper parts of peat profiles at Plynlimon in mid Wales (Mighall 2013) and Clogwyngarrog in north Wales (Grant 2012) which reflect dust

deposition as a result of agricultural and mining activities. Increases in lead, zinc and arsenic coincide with the development of the lead mining industry from the mid to late 1500s onwards. The increase in arsenic at Plynlimon probably reflects mining and coal combustion (Mighall 2013). There has also been a study from the Brecon Beacons chronicling habitat degradation which has been used to inform conservation ecology (Chambers *et al* 2013).

Pollution from earlier mining activity can also potentially have serious consequences for farming in the lowlands. Analysis of alluvial deposits following recent flooding has demonstrated contamination in catchments affected by historical metal mining in the Central Wales Orefield (Foulds *et al* 2014). This also has implications in terms of increases in flooding as a result of climate change.

Urban studies

- What were the living conditions of people in Welsh towns through the ages?
- What were their diets?
- What industries were based in urban contexts?
- What were the trades and trade networks of Welsh towns?

Potentially palaeoenvironmental studies can provide a wide range of information about life in Welsh towns in the past and there have been a number of recent studies, including preliminary assessments. For example, one recent study which has provided information about the cereal and animal contribution to the diet of townsfolk during the medieval period is that from excavations in the Deanery Yard, Bangor (Smith 2015, Smith *et al* 2013). Burnt animal bone displayed butchery evidence and may represent the remains of food prepared for the workforce building the cathedral in the 12th century, while changes in the bone assemblages in later deposits may reflect changes in diet. A bone assemblage dating largely to the post-medieval period and modern contexts, as well as a small medieval assemblage, from Flint is particularly valuable because of the limited post medieval faunal assemblages from north Wales and because of an interesting deposit of horse remains (Hodkinson and Madgwick 2015). Also from Flint, an assessment of charred and waterlogged plant remains from corn driers and the defensive town ditch suggests there is considerable

potential to gain both paleoenvironmental and palaeoeconomic information (Carruthers 2016b). Assessment of samples from the site of the new Cadw Harlech Castle visitor centre has also yielded charred plant remains of medieval post medieval date, as well as other remains, adding to the sparse archaeobotanical record for the post-medieval period in Wales (Carruthers 2014).

In south Wales assessment of samples from an organic deposit from the mill leat in Bute Park, Cardiff produced a range of domestic and industrial waste as well as waterlogged plant remains (Carruthers 2013c). The remains could potentially provide information about the environment, diet and industry in Cardiff during the post-medieval period. Two small faunal assemblages recovered along with human bones from churchyards in Swansea and Llantwit Major have also provided information. Post-medieval butchery waste was suggested at St Mary's Church, Swansea (Madgwick 2014) while the faunal assemblage from St Illtud Church, Llantwit Magor suggested domestic food waste consumed by inhabitants in the vicinity of the church and was dated to the medieval-post medieval periods (Madgwick and Faillace 2014).

Environmental investigations associated with the Newport ship by Nigel Nayling and colleagues have made a significant contribution to the investigation of trade and indeed international trade networks. The plant remains from the ship suggested a more southern European rather than British diet, while the presence of juniper leaves in the packaging dunnage suggested the ship originated from the Iberian peninsula (Carruthers 2013d). Dendrochronological analysis also suggested a similar origin for the construction of the ship (Nayling 2013). The fish record was also consistent with the ship travelling to Portugal, though one species, tusk, possibly indicated travel to more northern regions (Coard 2013b).

- Is there evidence for the importation of soils?

Climate Change

- What was the relationship between climate change and successive human communities?

As part of the Carmarthenshire Bogs Project, undertaken by Carmarthenshire County Council, an interdisciplinary investigation into the human and climatic impacts on Holocene peat bogs in SW Wales is currently being undertaken as a PhD by Kristy Holder at Swansea University.

- How did climate change influence human colonisation during the Late-glacial period in Wales?

  An investigation into rapid climate change in south Wales between 15,000 and 8,000 years BP using a multi-proxy approach is currently being undertaken as a PhD by Gwydion Jones at Swansea University. Again this is linked to the Carmarthenshire Bogs Project.

- What is the evidence for climatic change during the Holocene?

  Apart from vegetation changes in pollen records, alluvial records in river valleys also reflect climatic change. Flooding is related to climate change and there have been a number of recent publications by Professor Mark Macklin and colleagues at Aberystwyth University (e.g. Foulds *et al* 2014, Foulds *et al* 2016, Jones *et a*l 2010, Jones *et al* 2012, Macklin and Coulthard 2011, Macklin *et a*l 2012, Macklin *et al* 2013) concerned with the record for overbank floodplain sedimentation and river entrenchment in Wales during the Holocene.

  As a result of the storms of early 2014 submerged forests along the coast of Wales and elsewhere in the UK were uncovered. Welsh submerged forests have been sampled as part of a project undertaken by Durham and St Andrews Universities which involves the use of stable isotopes of tree biomass to generate palaeoclimatic and palaeoenvironmental information and produce a time-stratigraphic record of Holocene climate change from Wales. (https://sites.google.com/site/stablesibl/projects/archaeology)

  Evidence of more recent climate change in Wales and the rest of Britain has also been investigated using stable isotope analysis in oak tree-rings to reconstruct past summer temperatures (Young

et al 2012) and past summer rainfall between 1850-2010 AD (Young *et al* 2015).

Alluviation in non-tidal river valleys

- What has been the influence of river channel and floodplain development on the archaeological record, i.e. settlement, land-use, ritual practices and landscape, from the Palaeolithic to the present?

- What is the relationship between river alluviation, erosion episodes, climate change and land use change?

  As mentioned above, there have been a number of recent studies of alluviation in Welsh rivers by Professor Mark Macklin and colleagues (e.g. Foulds *et al* 2014, Foulds *et al* 2016, Jones *et al* 2010, Jones *et al* 2012, Macklin and Coulthard 2011, Macklin *et al* 2012, Macklin *et al* 2013) concerned with the relationship between river alluviation and entrenchment and climate and land use change.

Coastal alluviation and sea-level change

- What role have human communities played in changing coastal environments compared with 'natural' factors?

- At what date and in what environmental circumstances did human communities in the various regions of Wales first start to modify the coastal environment by digging drains and building sea-banks?

  A recent paper by Allen and Haslett (2014) has considered the natural site formation processes operating in the Severn Estuary and the effect of human intervention from the Roman time onwards. Drainage and sea defences, in response to sea-level rise, transformed the wetlands from areas suitable only for seasonal activities to areas that could be farmed and settled.

- The besanding of settlements is well known but more precise chronologies need to be established for dunes in Wales.
- Is there evidence for increased coastal dune-building and sanding-up during the Little Ice Age, AD1550-1850, and other episodes of climatic change?

There have been a few recent archaeological investigations where there is evidence for besanding, including Porth Clew, Brownslade, St Ishmael and Nant Farm, Porth Neigwl but the application of OSL dating to date Welsh dunes is still very limited. At Brownslade and Porth Clew mollusc evidence has also demonstrated the nature of the dune systems. For example, at Brownslade the early medieval burials were cut into a semi-mobile partly-vegetated dune system, which overlay an Iron Age arable soil, before a dry grazed grassland cover was established and the dunes stabilised (Brown and Bell 2011). Mollusc evidence from Porth Clew also indicated open grazed grassland and the lack of stabilisation layers indicated a mobile dune system (Walker 2011). At Nant Farm dune formation occurred after the eighth century AD (Smith *et al* forthcoming), while at St Ishmael the medieval settlement pre dates dune formation (Meek 2015). The effect of coastal sand inundation on British medieval coastal communities has also recently been reviewed by Brown (2015) and Griffiths (2015).

- How did marine transgression and regression phases affect human activities, especially in prehistory?
- How did humans adapt to the coastal environment?
- What is the evidence for the seasonal use of coastal wetlands in later prehistory and what was the nature of the economy practised?
- What was the relationship between wetland settlements and those on dry land?

Several recent investigations, ranging in date from the Mesolithic to the medieval period, reflect the use of coastal environments and resources. Evidence for the exploitation of coastal environments and seasonal activity during the Mesolithic has been demonstrated by the marine mollusc assemblages from Mesolithic midden sites at two rock shelters, Garreg Hylldrem, Porthmadog (Robinson 2012) and Snail Cave, Great Orme (Smith and Walker 2014), while the environmental conditions associated with the 'Lydstep pig' and human and animal footprints, dating to the Mesolithic-Neolithic transition, have been investigated at Lydstep (Murphy *et al* 2014). Palaeoenvironmental and studies at Redwick, Peterstone and other sites in the Severn Estuary (Bell 2013) have provided information about the relationship between human activity and coastal wetland environments during the Bronze Age. The evidence suggested a dry land – saltmarsh system of transhumance was operating during the

Bronze Age. Again the application of stable isotope analysis has proved informative and analyses from Redwick, Peterstone and Brean Down, on the English side of the estuary, supported the suggestion for seasonal activity (Bell 2013, Britton and Muldner 2013). The studies also highlight the need for stable isotope studies of animals from the same area of stable isotope studies of human bone to avoid misinterpretation of human diets.

In north Wales Bronze Age clearance activity was also evident in a pollen record from a peat bed identified during investigations associated with the Porthmadog Bypass across the Glaslyn Estuary (Hopla and Gearey 2013, Parry and Kenney 2013), while a palynological investigation from inter-tidal deposits at Porth Neigwl, Gwynedd, has provided information about possible human activity during the late Mesolithic/Neolithic in the wider region (Caseldine *et al* 2016b). Preliminary investigations at Borth, resulting from the construction of sea defences, indicate the changing conditions from the late Mesolithic through to the late Bronze Age (M. Bates & N. Nayling pers. comm.).

Other evidence for the use of marine resources has included the presence of marine shells and crab remains dating to the late Bronze Age at the copper smelting site at Pentrwyn, Great Orme (Madgwick 2015, Smith 2015), marine molluscs at the Roman settlement of Tai Cochion (Hopewell 2016), a medieval shell midden discovered on the route of the Porthmadog Bypass (Parry and Kenney 2013), evidence for fishing at the deserted medieval settlement at St. Ishmael (Browning 2015) and fish-weirs and traps off Sudbrook Point, Monmouthshire dating from the late eighth century onwards (Brown *et al* 2010).

In addition to the studies in the Severn Estuary and at Lydstep and Porth Neigwl, recent studies concerned with sea-level change include the publication by Roberts *et al* (2011) of investigations in the Menai Straits and a review of the evidence for sea-level change around the coast of the British Isles and the problems of modelling (Westley *et al* 2013). Current studies around the coast of Wales include a study being undertaken as a PhD thesis focussing on the archaeological context of sea level change in prehistoric South Wales by Rhiannon Philp at Cardiff University and a study by Caitlin Nagle, a PhD student at Sheffield University, which is concerned

with late Holocene sea level change in the Dysynni Valley, Gwynedd, through the analysis of diatom assemblages from sediment cores across the estuary. Ongoing research at Durham University and St Andrews is examining palaeoclimatic and palaeoenvironmental records from submerged forests in Wales through radiocarbon dating and tree-ring stable isotope analysis (https://sites.google.com/site/stablesibl/projects/archaeology). A preliminary study used tree-ring stable isotope analysis along with stratigraphic evidence, radiocarbon dating and other palaeoclimatic proxies to investigate local palaeoenvironmental and sea level change. (Pratt 2016).

Refresh Questions and Recommendations

It was generally agreed that, although progress has been made in the themes discussed above, there are still many gaps in the knowledge required to answer them fully and all the original themes and questions still remain relevant today. However some additional/revised questions have been suggested as well as various recommendations related to approaches and techniques.

Additional/revised questions

- How did upland and lowland landscape use change through time?
- Is there evidence for changing landscape use to increase productivity in the Early Iron Age?
- What is the evidence for changes in animal husbandry through time?
- What was the reason for the construction of burnt mounds and have they had different uses?
- What were the environmental effects of transhumance and lesser transhumance in both upland and coastal wetland environments, and did the practices attested in historic periods have prehistoric origins?
- What is the relationship between different types of site and sites of different social status during the medieval period, e.g. rural farmsteads, castles, ecclesiastical sites, towns etc.?

- How does the palaeoenvironmental record from, for example, pollen, seeds, bones, charcoal and tree-ring studies compare with the documentary record for the medieval and post-medieval periods?

- Did early miners/metallurgists destroy, modify or manage woodlands.

- How variable were the diets of townsfolk and how were they different from rural populations?

Recommendations

Environmental Context and Landscape Change

- An appropriate level of radiocarbon dating, along with the application of statistical analysis, is essential to enable the following which are priorities:
    - To enhance the chronological framework for human activity and the environmental record both for the Pleistocene and Holocene periods.

    - To refine the chronological framework for environmental change, including changes in vegetation, climate, sea-level, river alluviation, aeolian deposition and animal presence and extinction.

- Geoarchaeological modelling is required to identify topographic and sedimentary sequences which might yield archaeological and environmental data, particularly important are coastal and riverine contexts in relation to the Palaeolithic and Mesolithic. These need to be accompanied by ground-truthing to enable characterisation of sedimentary sequences.

- The scientific dating and investigation of new sedimentary sequences in caves or open-air sites, including Pleistocene sediment exposures in valleys and coastal locations, is a priority for the Palaeolithic though, for example, the sedimentary context of later archaeological material in caves is also important.

- The potential for palaeoenvironmental studies of Mesolithic sites is especially high where known sites adjoin wetland as in coastal areas

of South Wales and riverine and coastal areas of Pembrokeshire. Such contexts deserve particular attention.

- Palaeoenvironmental studies should be encouraged in areas where there has been little or no work to fill in gaps. In general there have been more pollen studies in the uplands rather than the lowlands and investigations in lowland areas where there are potentially suitable deposits should be a priority (e.g. Davies *et al* 2015).

- The early Neolithic tombs of SW Wales have attracted interest as pioneer communities and the evidence for environmental relations in these areas would repay attention.

- The tracking of bacterial ancient DNA in pollen and archaeological sediments could be used as an indicator of human presence in the past.

- Application of computer modelling to pollen data to reconstruct past land cover.

- A range of techniques, including multi-element analyses (e.g. Brown *et al* 2016), need to be applied to the investigation of burnt mounds. The formation processes also need to be considered (Hart *et al* 2014).

The development of agriculture and changing agricultural practices

- Radiocarbon dating of cereal grain is essential to date the beginnings of agriculture in Wales and changes in crop husbandry, e.g. how sudden were the changes across the Roman/Early Medieval period boundary? When was spelt wheat introduced?

- Environmental sampling should be undertaken on all sites to advance archaeobotanical and archaeozoological studies in Wales. This is important in identifying regional differences and similarities in farming practices and, for example, identifying the adoption of

new foods and cultural practices and trade networks, for example, during the Roman period.

- Charred grain occurs on a range of Neolithic and Bronze Age sites indicating agricultural and domestic activity and potentially the presence of settlements. The application of stable isotope analysis to charred grain to identify the use of manuring practices may help to determine whether there were small, permanent cultivation plots or shifting agriculture and how this relates to the archaeological evidence for settlement. Analysis of grain from more ephemeral settlement sites should be undertaken.

- Priority should be given to medieval sites with good documentary records and assemblages of biota to permit comparative studies.

- The wider application of biomolecular techniques offers particular potential for certain investigations. For example, the application of collagen peptide mass fingerprinting (ZooMS) to unidentifiable bone fragments to determine the species (e.g. Buckley *et al* 2014, Charlton *et al* 2016) has particular potential for the investigation of the transition from foraging, fishing and hunting to agriculture.

- DNA analysis should be used to target specific questions such as to distinguish domestic from wild animals and to identify genetic variation in animals.

- Stable isotope analysis of bone, as well as providing information about the diet of and use of resources by humans and population movement, is equally important in understanding animal diet and animal movement and can therefore inform such issues as the nature of agricultural regimes and trade networks. Animal isotope analysis is also important in the interpretation of human isotope data in the same geographic area.

Mining Activity and Industrialization

- Radiocarbon dating is a priority to date the beginnings of mining/metallurgy in Wales and impact on the environment.

Climate change

- Stable isotope analysis of tree-rings from submerged forests has the potential to provide palaeoclimatic data and needs to be explored further.

Coastal alluviation and sea-level change

- Prehistoric footprints are increasingly reported from the coast of Wales and it is important that when located they are fully recorded, their sedimentary and environmental context and date are established if the full value of this new source of evidence is to be realised.

- What is the environmental context and economy of Romano-British sites on the Gwent Levels. Can the dating of the various phases of drainage, particularly Roman Drainage be clarified.

General recommendations

- There is general agreement that there needs to be a palaeoenvironmental/environmental archaeology advisor to advise practitioners, curators, consultants and developers.

- There needs to be consistency in palaeoenvironmental strategy for developments such as wind farms, coastal defences etc.

- Where there are not resources immediately available to fund environmental work, or funding only permits initial assessment, the existence of samples for analysis and research should be made known via a central source.

Use of the Palaeoenvironmental Research Framework

The research framework has been used by developers and to gain funding for research (e.g. AHRC funding for an MA by Research (E. Treasure)). However the most recent versions of the research framework are not always cited.