

Palaeoenvironmental

Astrid Caseldine

Introduction

Of fundamental importance in understanding the archaeology of Wales is an understanding of the environment in which people lived and how they responded to environmental change, including climate change, and how they themselves affected the environment and landscape. This topic covers all periods and encompasses a number of specialist disciplines within the field of environmental archaeology. Studies of pollen, seeds, bone, molluscs, insects, soils and sediments can all provide a record of the environment and human activity. A considerable amount of work has been undertaken in the five years up until 2010 and is considered under the broad themes and questions previously identified. As well as traditional forms of analysis involving examination of the physical structure of the remains, increasingly the analysis of biomolecules (DNA, proteins, lipids and carbohydrates) and the technique of stable isotope analysis are extending the list of research questions that can be asked.

Environmental Context and Landscape Change

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

The relationship between human presence in Wales during different periods in the Palaeolithic and the environmental and climatic conditions is of particular interest. Of note are the environmental studies from Pontnewydd Cave (Aldhouse-Green *et al* 2012) as these provide environmental evidence indicating the conditions tolerated by Neanderthals at the north-western edge of their range. Studies included the application of stable isotope analysis to animal bone with a view to gaining information about aspects of diet, environment and climate (Jay *et al* 2012).

Much of the other work has focused on obtaining dates as part of the AHOB research programme to provide a more accurate chronological framework for human colonisation and faunal and environmental changes. This includes thermal ionisation mass spectrometric (TIMS: uranium/thorium) age determinations on stalagmites from Bacon Hole and other British sites to provide a better understanding of the chronological framework of Late Pleistocene faunal change during the earlier part of the Late Pleistocene (Gilmour *et al* 2007). Re-dating by radiocarbon using

ultra-filtration techniques of the red Lady of Paviland has led to a reconsideration of what the burial means in terms of colonisation and climate change (Jacobi and Higham 2008). Woolly rhinoceros bones from Goat's Hole (Paviland) and Coygan cave have been re-dated as part of an investigation to determine the extinction of woolly rhinoceros in Britain (Jacobi *et al* 2009) and targeted re-dating has resulted in a detailed reassessment of the last Glacial fauna from Coygan Cave. Wild horse from Cathole Cave has also been re-dated as part of the investigation of humans and animals during the Lateglacial (Jacobi and Higham 2009). Re-dating of humanly modified bone has taken place at Kendrick's Cave as well as Cathole Hole Cave.

Studies independent of archaeological work which provide information about the environment and landscape change include dating and correlating Late Pleistocene and Holocene alluvial sequences in Welsh river catchments (Jones *et al* 2006,) and modelling of relative sea-level change and deglaciation of the British-Irish ice sheet (Hubbard *et al* 2009). Lateglacial pollen studies have included a reconsideration of the events recorded at Traeth Mawr and the suggestion that they can be related to the five-fold subdivision of Greenland Interstadial 1, the survival of two oscillations being attributed to the climatic and ecological sensitivity of the site (Walker 2007a).

- How did the availability of resources influence Mesolithic occupation?

A significant advance has been made in our understanding of how the availability of resources influence Mesolithic occupation, especially in the coastal zone, through the multidisciplinary environmental studies undertaken by Professor Martin Bell (2007) and colleagues in the Severn Estuary and at Prestatyn in north Wales. This has included important dendrochronological work in refining the chronology of coastal change in the late Mesolithic and Neolithic (Nayling and Manning 2007). The studies in the Severn estuary have also added to our understanding of seasonal exploitation, including evidence for the use of plant resources (Dark 2007) during this period. Investigation of the annually laminated sediments containing footprint tracks also indicated seasonal activity (Dark and Allen 2005). Studies such as the Arfordir project undertaken by Dyfed Archaeological Trust in conjunction with Pembrokeshire National Park, RCAHMW and Birmingham University have helped to identify further areas and sites for detailed investigation. The West Coast Submerged Land Project undertaken by Birmingham University with input from the Welsh Archaeological

Trusts has resulted in palaeolandscapes maps for the Bristol Channel and Liverpool Bay for both the Mesolithic and Palaeolithic (Fitch and Gaffney 2011).

Other palaeoenvironmental investigations which indicate the environmental conditions, and hence the resources available for exploitation, have included a study of the sea-bed in the Menai Straits by Mike Roberts at Bangor University. Investigations have also taken place in Milford Haven by Martin Bates and colleagues (Bates *et al* 2007).

Investigation of the environmental conditions away from the coast include pollen studies at Gors Fawr and Esgyrn Bottom in Pembrokeshire (Fyfe 2007), Esgair Ffraith in mid Wales (Walker *et al* 2006) and Moel Llys y Coed, Denbighshire (Grant 2007). Although not directly related to an archaeological site such studies, notably through the presence of charcoal, may suggest human activity and exploitation of the environment during the Mesolithic.

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

The relationship between Neolithic and Bronze Age funerary and ritual monuments and the surrounding environment is another area where there has been notable progress. Several pollen investigations have been undertaken in relation to the survey carried out during the Funerary and Ritual Project as well as in association with follow-up excavations. They have included the analysis of pollen from nearby peat deposits, such as Craig y Dullfan (Caseldine and Griffiths 2009e), and/or buried soils associated with monuments, for example Fan Foel (Caseldine and Griffiths 2006a), Corndon Hill round barrow (Britnell *et al* 2008) and Waun Llanfair (Caseldine 2013). Charcoal and plant macrofossil evidence add to the environmental record at the latter sites. Other integrated archaeological and environmental investigations include those undertaken in the Strumble- Preseli region (Darvill *et al* 2006, Fyfe 2005, 2007) and as part of the Aber Revelations Project (Fyfe and Law 2008). A pollen site at Moel Llys Coed (Grant 2009) was investigated as part of the Uplands Archaeology Initiative. Where pollen evidence is not available, for example in the Walton Basin (Caseldine and Griffiths 2009a, 2009r), charcoal studies from sites of different date within the same area may give some indication of the environmental conditions and environmental change.

One noteworthy area of research has been the palaeobotanical evidence for ritual activity in Wales. Pollen evidence from investigations at Fan Foel (Caseldine and Griffiths 2006a) and Buttington Cross (Daffern 2009) have suggested the possibility of floral tributes associated with cremations. This is of particular significance because of similar evidence from Scotland. Evidence of burning activity at Fan Foel and Corndon Hill (Britnell *et al* 2008) may also have ritual significance. Equally charcoal and charred plant remains associated with a cremation urn from Llanmaes (Caseldine and Griffiths 2010a) and charcoal from a pit at Buttington Cross (Clapham 2009b) may indicate ritual activity.

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

There have also been developments related to the question of continuity of land use from the Romano-British to the early Medieval period and the question of the crops grown during these times. Pollen studies provide some insight into the question of continuity of land use and there have been a number of studies (e.g. Cors Caron (Lomas–Clarke and Barber 2007), Talley Lakes (Yates-Sabren 2008), Wentwood (Brown 2010), Moel Llys-y-coed (Grant 2009)) which have provided further evidence for the impact of human activity on the environment and land use changes over the Romano-British to early Medieval period. However, most of these studies have been undertaken independently of any archaeological excavation. The pollen evidence from the Short Dykes project is therefore of particular significance as results from the radiocarbon dating programme suggest an early medieval date for their construction (Hankinson and Caseldine 2006). The pollen record associated with the excavations at the Late Prehistoric/Roman lead smelting site and medieval trackway at Llangynfelyn also provides a record for this period (Caseldine *et al* 2008) as does the recent record from the central dome of Borth Bog (Mighall *et al* 2009b). Several of these studies also provide evidence pertaining to the Iron Age/Romano- British boundary.

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

Several of the studies covering the Romano-British-Early Medieval boundary also provide evidence pertaining to the Iron Age/Romano-British boundary.

Charred plant remains provide a more detailed line of evidence for continuity or change in the types of crops grown, both between the Roman and early Medieval periods and the Iron Age and Romano-British periods, and again there have been a number of useful studies, helping to establish a picture of crop husbandry during these periods (see below).

- What were the environmental conditions associated with wetland sites?

Environmental conditions are of key significance in the interpretation of wetland sites. Several major studies, involving a range of palaeo-environmental analyses, have taken place in the Severn Estuary including the Mesolithic sites at Goldcliff and Llandevenney (Bell 2007), the Bronze Age sites at Redwick and Peterstone (Bell forthcoming), the Barland's Farm Romano-Celtic Boat (Nayling and McGrail 2004) and the probable Neolithic footprint site at Kenfig (Bennett *et al* 2010). Wetland site investigations elsewhere have included the shell middens at Nant Hall, Prestatyn (Bell 2007), the Neolithic site at Abercynafon (Caseldine and Earwood 2004), the late prehistoric/Roman lead smelting and medieval trackway site at Llangynfelyn (Caseldine *et al* 2008, Smith *et al* 2007, Caseldine *et al* forthcoming) and the burnt mound site at Nant Farm (Caseldine and Griffiths 2009b, Caseldine in prep.).

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?

Establishing the beginnings of cereal cultivation and animal husbandry during the Mesolithic/Neolithic transition in Wales has continued to be a focus of investigation with pollen records from Goldcliff East (Dark 2007, Timpany 2007), Redwick (Timpany 2005), Llandevenney (Brown 2007) and Prestatyn (Taylor and

Caseldine 2007) as well as others, for example Moel y Gerddi (Innes *et al* 2007) and Moel Llys y Coed (Grant 2007), providing further data for the later Mesolithic and early Neolithic. However, because of the difficulties associated with cereal pollen it is evident that the only way to establish with any degree of certainty when cereal cultivation commenced in Wales is by the dating of charred cereal grain. The dating of charred grain from an early Neolithic house at Parc Bryn Cegin, Llandygai (Kenney 2008, Schmidl *et al* 2008) is therefore of significance not only in terms of dating the building but in helping to determine the establishment of cereal cultivation in Wales.

Following on from earlier work at Parc le Breos Cwm, Gower (Richards 1998) and a number of cave sites in Wales, stable isotope studies of human skeletons from Prestatyn and Gop Cave (Schulting and Gonzalez 2007) have provided further evidence that Neolithic people had a largely terrestrial diet, with only limited evidence for the use of marine resources compared with the Mesolithic.

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

There has also been some progress in the investigation of farming activity during the Neolithic and earlier Bronze Age in Wales. The investigation of charred cereal remains from Neolithic settlements, along with animal bone if it survives, is also of importance in the consideration of how sedentary or mobile Neolithic populations were. Environmental evidence from excavations such as Parc Bryn Cegin, Llandygai (Kenney 2008, Schmidl *et al* 2008) contributes to this debate while analyses from sites such as Parc Cybi (Kenny 2007) and Borrass Quarry (Grant and Jones 2009) may add further evidence.

The survival of animal bone is generally poor on prehistoric sites in Wales. Hence the recovery of a substantial assemblage of animal bone along with Neolithic pottery as part of the Goldsland Caves research Project (Aldhouse-Green and Peterson 2007) is of particular value. The possibility that parts of certain animals were deliberately incorporated within the burial deposits is also being examined. The survival of animal bone and footprint tracks in the clays and silts of the Severn Estuary, for example at the Bronze Age sites of Redwick and Peterstone, have also provided useful information about livestock farming practices (Bell forthcoming.) and together with pollen and stable isotope studies of bone and enamel have demonstrated the use of saltmarsh. The stable isotope studies have also demonstrated the need for stable isotope studies

of animal bone from the same area as stable isotope studies of human bone to avoid misinterpretation of human diets (Britton *et al.* 2008, Britton and Müldner forthcoming).

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

The recovery of further archaeobotanical evidence from archaeological sites has added to our understanding of continuity of agricultural practices, when changes in crop husbandry occurred and the nature of the changes. Multiperiod sites, e.g. Parc Bryn Cegin (Kenney 2008), or investigations of sites of different date within an area, e.g. sites investigated as a result of the A497 improvement (Berks *et al* 2007) and the gas pipeline from Felindre to Tirley (e.g. Carruthers 2008a), are particularly useful in determining changes within an area. Along with the archaeobotanical evidence the palaeoenvironmental evidence (e.g. Walker and Jones 2007a) from the gas pipeline excavations should make a major contribution to the investigation of past agriculture and land use in south Wales. The investigation of defended enclosures in south Ceredigion and north Pembrokeshire has provided archaeobotanical evidence from the Late Bronze Age/early Iron Age through to the Roman period in that area (Caseldine and Griffiths 2007a, 2009c, 2009d, 2011), while detailed analyses of charred grain assemblages from Llanmaes in the Vale of Glamorgan may provide information about the status of different crops from the early Bronze Age through to the Romano-British period (Caseldine and Griffiths 2005a, 2006b, 2010a). Other sites which have yielded information about crops during the Roman period include Llandeilo Roman fort (Caseldine and Griffiths 2007b) and a corn drier at Tremadog (Kenney 2005). Excavations at Caerleon have included the recovery of charred plant remains from Roman and post Roman deposits (Caseldine and Griffiths 2009t, 2013).

Information about the nature of arable farming during the early medieval period in Wales has been recovered from several sites, including sites such as Afon Wen (Berks *et al* 2007) and Parc Bryn Cegin, Llandygai (Kenney 2008, Schmidl *et al* 2008) in north Wales and West Angle (Caseldine and Griffiths 2007c) Newton (Caseldine and Griffiths 2004a), South Hook (Carruthers 2010), Maenclochog Castle (Carruthers 2008b) and Caerleon (Caseldine and Griffiths 2013) in south Wales. Changes hinted at during the Roman period become clearly established during the early medieval period. Plant remains from Dryslwyn Castle have added to the record for cereal growing during the medieval period (Huntley and Daniel 2007) and

along with other studies have provided information about food production and consumption. The evidence obtained from the large assemblage of animal bone as well as providing information about animal husbandry included information about butchery practices, game animals, domestic and wild birds, fur-bearing animals and companion animals (Gidney 2007) as well as fish (Locker 2007) and shellfish (Huntley 2007).

Favourable soil conditions at Llanmaes in the Vale of Glamorgan have permitted the survival of a large bone assemblage, of importance because of the poor bone preservation, as noted previously, on most Welsh prehistoric sites. The bone assemblage, apart from providing information about the agricultural economy, is also of particular value in the interpretation of the social importance of the site (Lodwick and Gwilt 2005). Another site in the Vale of Glamorgan which has yielded both charred grain and animal bone is the late Iron Age and Roman farmstead at St Athan (Barber *et al* 2006).

An area of palaeoenvironmental investigation which has received little attention in Wales is that associated with field systems. One attempt to rectify this has been The Early Prehistoric Fields Project undertaken by Gwynedd Archaeological Trust which has included palaeoenvironmental work.

- 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?

Palaeobotanical studies may also contribute to our understanding of the economy of medieval and post-medieval farms in the uplands and the role of climatic and other environmental changes in farm abandonment and changes of agricultural regime, along with social and economic factors. Recent pollen studies such as those at Ynys Ettws (Caseldine 2006), Moel Rhiwllug (Grant 2007), Moel Llys-y-coed (Grant 2009), Craig y Dullfan (Caseldine and Griffiths 2009e), Hirwaun Common and Mynydd Llangatwg (Chambers *et al* 2007a, 2007b) provide information about changes in grazing practices in the uplands and cereal cultivation. Environmental evidence for cereal cultivation from deserted rural settlement sites in the uplands remains limited but includes that from Ynys Ettws where charred cereal and waterlogged plant remains, as well as cereal pollen, indicated cultivation in the area. The evidence from Ynys Ettws and the post-medieval settlement of Tro'r Derwlyn has also contributed to the debate about transhumance and seasonal occupation.

Mining Activity and Industrialization

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

Wales is of primary importance in the study of the history of metal-mining in the UK and there has continued to be significant progress in identifying prehistoric and historic mining activity in palaeoenvironmental records, notably at Rhandirmwyn, Carmarthenshire (Mighall *et al* 2007), Craig y Mwyn Mine, Llanrhaeadr-ym-Mochnant, Powys (Mighall *et al* 2008), and at sites adjacent to Borth bog including Llangynfelyn lead smelting site, near Erglodd Roman fort, (Caseldine *et al* 2008, Mighall *et al* 2009), in a central core from Borth Bog and a site close to Llancynfelin mine (Mighall *et al* 2009b).

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

There has been further progress in determining the impact of iron-working on the landscape during the period from the Iron age to Medieval times. Combined archaeological and palaeoenvironmental studies (charcoal, geochemistry, pollen) at a 14th century bloomery, Llwyn Du, in Snowdonia has made an important contribution to our understanding of the possible impact of iron-working on the surrounding woodland through fuel supply and woodland management (Mighall and Crew 2005, Mighall *et al* 2009, Crew and Mighall 2010). Mineral magnetic measurements were used to detect ironworking activity in the peat cores (Mighall *et al* 2009). An 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 2010). This study is of particular value because of the rarity of metal working sites of this date in Wales.

- What impact did post-medieval industrialisation have on the surrounding environment and what is the longevity of its environmental signature?

The impact of post-medieval industrialisation on the surrounding environment and the longevity of its environmental signature has been another area where there has been some further advances. Work on blanket mires and raised bogs has involved the investigation of factors influencing vegetation change and mire degradation. Studies of blanket mire degradation have demonstrated a major vegetation change, i.e. an increase in

Molinia, post-dating the industrial revolution. The results suggest that, as well as other factors, atmospheric pollution from industrial activity in the South Wales valleys may have been responsible (Chambers *et al* 2007a, 2007b). The encroachment of *Molinia* and *Betula* on raised bogs in Wales during the twentieth century is thought to relate to pollution from agricultural activities and the combustion of fossil fuels (Hughes 2005, Hughes *et al* 2007). Changes in *Sphagnum* moss species at Cors Caron may be a response to airborne pollution, grazing or fertilization of the bog surface by *Betula* litter. Work at Talley Lakes also suggests that increases in copper, zinc and lead may represent atmospheric pollutants from the metal smelting areas of south Wales, although it could relate to more local mining activity (Yates-Sabren 2008).

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?

There are a number of questions related to urban studies including the living conditions of townfolk, their diet, the types of industry and trade and trade networks.

Studies within towns include examination of plant and animal remains from a probable late 15th century building in Presteigne (Priestly 2006, O'Brien 2005, Hancox 2005) and plant remains from the moat at Carmarthen Castle (Caseldine and Griffiths 2004b) and the outer bailey ditch of Swansea Castle and occupation deposits, including middens, at Goat Street, Swansea (Griffiths 2009). However, environmental work on urban sites has been comparatively limited. One major area of investigation concerned with trade and trade networks has been the investigation of the Newport ship by Nigel Nayling and colleagues.

Climate Change

- What was the relationship between climate change and successive human communities?
- How did climate change influence human colonisation during the Late-glacial period in Wales.

The relationship between climate change and successive human communities is of central importance. Of particular interest is the influence of climate change on human colonisation during the Late-glacial period in Wales. Radiocarbon evidence from Gough's Cave in

south-western England for the Magdalenian re-colonisation of the British Isles has been compared with the evidence for interstadial warming from Llanilid (Walker *et al* 2003) in south Wales (Jacobi and Higham 2009). Re-dating of humanly-modified fauna from sites in Wales has taken place as part of the AHOB investigation of re-colonisation and climate change.

Late-glacial studies have included a reconsideration of the events recorded at Traeth Mawr and the suggestion that they can be related to the five-fold subdivision of Greenland Interstadial 1 recorded in the GRIP event stratigraphy (Walker 2007a). The survival of two oscillations at Traeth Mawr is attributed to the climatic and ecological sensitivity of the site. Late-glacial and early Holocene climate and environment have also been investigated using stable isotopes in Welsh tufa (Garnett *et al* 2006).

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

Interest in climate change is not confined to only the Late-glacial period and studies that provide evidence for climate change during the Holocene include investigation of changes in peat stratigraphy, for example at Cors wern Goch, Coedd Aber NNR (Hughes and Grant 2005, 2006), while the demise of *Sphagnum austinii* (*S. imbricatum*) moss at Welsh peat sites, as well as at other sites in Britain, may be a response to climate change (Hughes *et al* 2007). Later changes in the pollen and sediment chemistry records from Talley Lakes have been attributed to the 'Little Ice Age', as well as other historical events (Yates-Sabren 2008). Studies of river response to environmental change have also been attributed to climate change (see below).

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?

The influence of river channel and floodplain development on the archaeological record, from the Palaeolithic to the present and the relationship between river alluviation, erosion episodes, climate change and land use change are also areas where there have been further advances. Work has included an investigation of Holocene river development in the lower Usk Valley with particular reference

to Caerleon (Johnstone *et al* 2008). Research by Professor Mark Macklin and colleagues into river dynamics and environmental change has also continued in a number of other catchments in Wales (Johnstone 2004, Jones 2007, Brewer *et al* 2009, Jones *et al* 2010) and included investigations in the Tywi Valley as part of the Exploration Tywi! Project. Of particular note in the investigation of the relationship between river behaviour, climate change and anthropogenic activity is the development of a data-base of radiocarbon-dated Holocene fluvial deposits in Great Britain (Macklin *et al* 2005, 2010, Johnstone *et al* 2006).

Coastal alluviation and sea-level change

- What role have human communities played in changing coastal environments compared with 'natural' factors?
- The besanding of settlements is well known but more precise chronologies need to be established for dunes in Wales.
- 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?
- 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?

There are a number of issues related to coastal alluviation and sea-level change and archaeology. These include the role of human communities in changing coastal environments compared with 'natural' factors, including modification by drainage ditches and sea-banks, as well how they adapted. Related to this is the question of seasonal use of coastal wetlands in later prehistory and the nature of the economy practised and the relationship between wetland settlements and those on dry land. Fundamental to all of this is how marine transgression and regression phases affected human activities, especially in prehistory, and work has continued on modelling relative sea-level changes since the Last Glacial Maximum

for the British Isles (Shennan *et al* 2006). Investigations in the Severn Estuary have also led to a revised sea-level curve being suggested for the area (Bell 2007), as well as evidence for resource exploitation and the relationship between wetland and dry land settlements, not only for the Mesolithic period (see above, Bell 2007) but also for the Bronze Age (Bell forthcoming). Further investigations of fish traps have indicated the importance of fishing during the medieval period in the Severn Estuary (Brown *et al* 2008).

Other studies in the Severn Estuary have focused on factors involved in much later events, namely the flood event of 1607 and whether a storm surge or tsunami may have been the cause (Horburgh and Horritt 2006, Lewis 2007, Bryant and Haslett 2007, Skellern *et al* 2008). Further west an investigation of lithostratigraphic and chronostratigraphic evidence from sites in the Loughor estuary has focused on sea-level change in the last 2000 years and the processes involved (Edwards 2006). Investigation of the peats and clays associated with probable Neolithic footprints at Kenfig Sands near Porthcawl indicated the changing conditions prior to and the conditions contemporary with the formation of the footprints (Bennett *et al* 2010). Human and animal footprints and the associated environmental conditions have also been investigated at Lydstep in Pembrokeshire (Caseldine in prep.)..

In north Wales research has included elucidating the nature of Holocene sea-level and coastal change in the Menai Straits by Mike Roberts as well as the relationship between late Mesolithic and early Neolithic shell middens and sea-level change in the Prestatyn area and the resources available for exploitation (Bell 2007, Armour-Chelu *et al* 2007).

- Is there evidence for increased coastal dune-building and sanding-up during the Little Ice Age, AD1550-1850, and other episodes of climatic change?

In addition to the other issues another area which would benefit from further palaeoenvironmental research is that of increased coastal dune-building and sanding-up during the Little Ice Age, AD1550-1850, and other episodes of climatic change. Studies of archaeological sites where the associated environmental changes, including besanding, have been investigated include Brownslade (Groom *et al* 2011) and Porth Clew (Schlee 2008, 2009). Radiocarbon dates at these sites provide evidence of when besanding occurred, however the use of OSL to date Welsh dunes is

still very limited although work has included the dating of deposits near Harlech (Duller *pers. comm.*).

Priorities and Recommendations

The priorities previously identified and discussed above remain important. There are, however, several additions to the research questions and themes, as well as recommendations regarding approaches and techniques that could be applied or given greater emphasis and these are listed below.

Environmental Context and Landscape Change

Research Questions

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

Approaches and techniques

- Dating of pollen records from speleothems (secondary cave calcite deposits) using thermal ionisations mass spectrometric (TIMS) U-Th dating offers the possibility of producing well-constrained palaeoenvironmental records beyond the ~40kyr limit of ¹⁴C dating.
- The tracking of bacterial ancient DNA in pollen and archaeological sediments could be used as an indicator of human presence in the past.
- The contribution of charcoal analysis to environmental reconstruction, particularly where other evidence such as pollen and molluscs does not survive, has been under-valued and needs greater emphasis.
- There is a need for increased use of Geographical Information Systems in environmental reconstructions in Wales.

The development of agriculture and changing agricultural practices

Research Questions

- What is the relationship between the Roman army and native populations in terms of agricultural supply, particularly at such sites as Caerleon?
- What was the relationship between Roman towns and the surrounding regions?
- What is the evidence for the development of horticulture in Wales?

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

Approaches and techniques

- Charred cereal grain needs to be dated to determine the arrival and spread of different crops in Wales from the Neolithic onwards.
- Stable isotope analysis of charred grain to determine whether manuring has taken place.
- Animal bone is frequently poorly preserved on Welsh sites, particularly prehistoric, because of the soil conditions but where it survives DNA analysis should be used to target specific questions such as to distinguish domestic from wild animals and to identify genetic variation in animals, for example deer, in Wales and the UK .
- Stable isotope analysis of faunal remains as well as human remains should be undertaken to investigate diet and to compare with ceramic lipid analysis.

Social organisation and belief systems

Research Questions

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

Social organisation and belief systems were not identified as a separate theme in the 'All Wales Final Document', although ritual activity was in the 'National Seminar Paper' and there is both plant and animal evidence relevant to these topics, and need greater emphasis.

Mining Activity and Industrialization

Research Questions

- What is the evidence for silver mining in Wales?
- 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?

Approaches and techniques

- Lead isotopes can help to discriminate between different ore sources, although British lead ores have overlapping isotopic signatures and further work is required.

Urban studies

Research Questions

- Is there evidence for the importation of soils?

Coastal alluviation and sea-level change

Approaches and techniques

- Survey and mapping of inter-tidal and offshore palaeo-landscapes.
- Monitoring shoreline archaeology and coastal erosion using appropriately trained volunteers to identify archaeological and palaeoenvironmental sites.

Climate change and Alluviation in non-tidal river valleys

Although no additional questions have been identified, the role of palaeoenvironmental studies is recognised as particularly relevant at the present time and needs to be emphasised.

Conservation and management

Environmental groups and organisations need to be aware of the possible impact of management practices on the palaeoenvironmental record and the significance of the latter to archaeology as well as present environments and needs more emphasis.

Conclusions

The relationship between people and the environment throughout all archaeological periods is of fundamental importance and is exemplified by present day concerns about climate change, river and coastal flooding and coastal erosion. Further progress has been made in the investigation of environmental context and landscape change, the development of agriculture and changing agricultural practices, mining activity and industrialisation, urban studies, climate change, alluviation in non-tidal river valleys, coastal alluviation and sea-level change, to which needs to be added social organisation and belief systems. Investigations involving pollen, seeds, bone, molluscs, insects, soils, sediments and geochemical analyses have all contributed to the palaeoenvironmental record, depending on the survival of the evidence. Supplementing these studies, increasingly studies involving stable isotope analysis and the analysis of DNA, lipids, proteins and carbohydrates (biomolecules) are providing additional information about the environment, climate and diet and increasing the range of questions that can be addressed, such as those involving genetic variation and domestication.