# Towards an Environmental History of Argyll & Bute: A Review of Current Data, Their Strengths and Weaknesses and Suggestions for Future Work

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## Introduction

Communication between archaeologists and scientists engaged in environmental reconstruction has not always been easy. Archaeology recognises the need to comprehend landscape change but informed use of the data generated by natural scientists is still unusual in many periods of prehistory, and certainly within the historic period.

Argyll & Bute has been fortunate, compared to most of Scotland, in having had a number of syntheses or reviews of palaeo-environmental data in recent years. Graham Ritchie's invaluable *Archaeology of Argyll* (1997) has a chapter by Donald Sutherland, then a leading figure in the Scottish Quaternary (the last *c*. 2.3 million years of Earth history). Quaternary geologists are inevitably drawn to the study of glaciers and glaciation, before *c*. 11700 cal years ago, a period until very recently (Ballin *et al* 2010; Wicks & Mithen 2013) thought to be devoid of human settlers and so of little interest to most archaeologists. Nevertheless, Sutherland (1997) spent >50% of his review on the period older than *c*. 11700 cal years ago in Argyll, and there is no mention at all of people in the past. My own review (1999) in the RCAHMS inventory of Kilmartin Glen was confined to that area and could add little more about people in the past. Gillen (2004) in Donald Omand's *The Argyll Book* managed only one page of 16 on the postglacial period.

Quaternary scientists themselves have visited Argyll & Bute four times in the last 30 or so years, to Islay and Jura (Dawson 1983), to Mull (Walker, Gray & Lowe 1985), to the Oban region (Walker, Gray & Lowe 1992) and just tip-toeing into the region in 2003 (Evans 2003) but only one contribution to the field guides to these areas includes a chapter on archaeology, that in 1992 by Clive Bonsall.

There is a serious point here, that archaeology is often seen as different to the Quaternary and *vice versa* when they are not. They should be inseparable. This review will attempt to redress the balance somewhat. It will do so by initially 'packaging' together what we know in the region about the end of the last glaciation before going into more detail about environmental change within the subsequent Holocene epoch.

## The Devensian Lateglacial period in Argyll & Bute

The last British-Irish Ice Sheet covered all of Argyll & Bute (Bradwell *et al* 2008a; Hubbard *et al* 2009). Current climatic models provided by high-resolution analyses of annual layers of ice in Greenland's ice-sheet (Lowe *et al* 2008; Rasmussen *et al* 2008) describe initial warming of the North Atlantic region at *c*. 12700 cal BC. Much deglaciation occurred before this in a cold but dry climate. Chironomid assemblages suggest that mean July temperatures were lower than *c*. 7.5ºC before the Windermere Interstadial, before *c*. 12350 cal BC and reached *c*. 12ºC after this (Turney, Harkness & Lowe 2007): coleopteran data (Coope *et al* 1998) suggest temperatures of *c*. 18ºC in Windermere Interstadial summers.

With warming, soils began to support vegetation and to store organic matter. Biological productivity increased in lake basins. Devensian Lateglacial pollen records in Argyll & Bute are depicted in Map 1. They uniformly record the colonisation of, first, grasses, sedges and herbs of bare- and disturbed-ground character. A closed vegetation cover may have formed but comparative aridity maintained populations of plants we think of as coastal like sea plantain. Heathland developed rich in crowberry, a heather adapted to dry conditions. Juniper and birch migrated but a closed woodland cover probably did not form.

The earliest shorelines to be formed during deglaciation are found at altitudes of around 40m OD (Ordnance Datum) (Sutherland 1997) because the weight of the last British-Irish Ice

Sheet forced the British Isles below contemporary global sea level, which itself reached 120m below present. With deglaciation, the land rose faster than the sea itself rose, leaving elevated shorelines. A calibrated $^{14}C$ assay on the abandonment by the sea of one coastal basin in Knapdale at 31.3m OD of 15860-14820 cal BC is, if correct, the earliest for deglaciation in the region (Shennan *et al* 2006). At other localities in western Scotland, however, shorelines this high and higher are younger, *c*. 13000 cal BC (Shennan *et al* 2006).

Temperatures declined throughout the Windermere Interstadial to around 11ºC. Evidence from chironomids suggests three falls in mean July temperature of between 0.5 and 3 ºC. Around 11950 cal BC mean July temperatures plummeted to below *c*. 7.5ºC. Plant communities were destroyed. Periglacial conditions promoted heavy soil erosion and on steep slopes, talus or scree accumulated (Ballantyne & Kirkbride 1987; Dawson, Lowe & Walker 1987).

Sea level fell within the Windermere Interstadial. Some areas show the sequential fall over time, as on Oronsay (Jardine 1977), in Kilmartin (Gray & Sutherland 1977) and in the Mhoine Mhor (Peacock *et al* 1977). Shorelines eroded by the sea become more coherent and continuous. Contemporary shorelines are seen to fall in altitude from north east to south west (see Figure 2.1: Sutherland 1997) because the land around Rannoch Moor rose faster than land on Kintyre. A prominent shoreline, the Main Rock Platform, was mapped by Gray (1974, 1975, 1978) and Dawson (1984) falling from around 12m OD in inner Loch Etive to 0m OD around Campbeltown. This shoreline is thought to have formed in the periglacial climate of the Loch Lomond Stadial (Gray 1978).

Marine sediments relating to the higher sea-levels of the Windermere Interstadial have been recorded in a number of places, including the central valley of Bute, beneath Campbeltown and from the head of the tidal Loch Gilp at Lochgilphead to the entrance to the lower Add valley and under the Crinan Canal, and at South Shian (Peacock 1983, 1989; Peacock *et al* 1977). These are the Clyde Beds. They contain marine faunas that can define sea surface and deep water marine temperatures in the Devensian Lateglacial. Peacock (1983) estimated from modern analogues that in the early part of the Windermere Interstadial summer sea surface temperatures (SST) were close to present but some 3°C at 25m depth: winter SST was near freezing. Later, perhaps around 10800 cal BC, summer SST may have exceeded 13°C.

An ice sheet centred on Rannoch Moor re-formed towards the end of the Windermere Interstadial (Golledge, 2006, 2010) or if like ice sheets further north, began to readvance (Bradwell *et al* 2008b). Valley glaciers advanced along Loch Etive to the confluence with Loch Linnhe (Gray 1995), down Loch Awe as far as Ford (Gray & Sutherland 1977; Tipping 1989) and to the head of Loch Fyne (Sutherland 1984). A separate ice sheet formed on Mull (Ballantyne 2002) and a rock glacier emerged on Jura (Dawson 1977). Loch Lomond Stadial ice rucked up marine shells with an age around 9700 cal BC at the west end of Loch Creran (Peacock *et al* 1989) and incorporated organic mud just east of Loch Lomond at *c*. 10500 cal BC (Rose, Lowe & Switsur 1988). The climatic change to the Holocene epoch at around 9750 cal BC occurred in a matter of decades or a few years (Taylor *et al* 1993; Alley 2000).

## The Holocene Epoch in Argyll & Bute

### Climate change

Tipping *et al* (2013) have recently summarised the evidence for climate changes that are likely to have affected Scotland and the people living in it. The current paradigm is that climate in the past changed rapidly or even abruptly, as in the switch from the cold of the Loch Lomond Stadial to the warmth of the earliest Holocene, though infrequently (Mayewski *et al* 2004). Current reconstructions stress short 'moments of crisis' separated by long periods of stability or smaller climatic excursions. The rapidity of the crises gave little time for people to adapt, and prolonged stability meant that coping strategies will have been forgotten (Tipping 2005).

Mechanisms of change at slow temporal scales are the precisely rhythmic very long-term variations of the Earth round the sun, called Milankovitch cycles. At shorter temporal scales variations in solar activity are probably a key driver but feedback processes with many properties of the Earth's surface are complex. Periods of rapid climate change are re-organisations of the atmospheric circulation system, not simply changes in temperature or precipitation. The North American or Laurentide ice sheet, for instance, collapsed abruptly at *c*. 6200 cal BC and altered global atmospheric circulation through its effect on North Atlantic Ocean circulation, probably shutting down the "gulf stream". Stager & Mayewski (1997) and

Debret *et al* (2009) suggested that the present atmospheric circulation system only emerged with the collapse of this huge ice sheet. Before *c*. 6200 cal BC weather charts, could people have plotted them, would have looked very different to today.

The west coast of Scotland experiences alternating cold-dry-still 'continental' weather when a blocking high pressure zone settles over the North Sea and the near-continent, and warm-wet-stormy weather from the Atlantic. Today, these alternate frequently, determined in large part by semi-periodic changes in the North Atlantic Oscillation (NAO), a term which describes the oscillating system of quasi-stable low pressure zones over Iceland and high pressure zones over the Azores. The NAO varies in strength, and our weather also varies because of this, but Trouet *et al* (2009) have suggested that the climate can get locked into one or other of these phases for very long periods. So the warm Middle Ages in north west Europe, for example, have been seen as one 200-year or so period when westerly winds prevailed on a strong jetstream, with the subsequent 'little ice age' characterised by cold easterlies.

Tipping *et al* (2013) tried to summarise for archaeologists and historians the types of data being assembled to construct a new chronology of climate change relevant to Scotland. Charman (2010) summarised data for the British Isles and Swindles *et al* (2013) have assembled data for Ireland. Many data-sets are being generated from ocean and sea-loch sediment to the west of the Argyll coast because the North Atlantic Ocean is fundamental to understanding these patterns (below). No modern-standard terrestrial climate proxy records exist for the region. Undisturbed parts of the raised moss of the Moine Mhor are suitable for generating a proxy record of hydrological change in late prehistory and history (cf. Charman *et al* 2006), which could become important in linking the quite different records between Ireland and Scotland in the later Neolithic and Bronze Age (Swindles *et al* 2013). The invasion and demise of Scot's pine populations on blanket peat in prehistory on Rannoch Moor (Bridge *et al* 1990) are best interpreted as responses of these trees to hydrological change but detail is lacking. Scots pine trees preserved in peat bogs are, however, a critical data source for annually resolved palaeo-climatic records (Bridge *et al* 1990; Moir *et al* 2010).

Schematically, we might recognise the following periods of climatic deterioration as critical:

- Early Holocene climatic events include short-lived deteriorations in climate before *c*. 9300 cal BC, at *c*. 8350 cal BC and *c*. 7550 cal BC (Bos *et al* 2007; Whittington *et al* 2015)
- The major early Holocene climatic reversal, the 8.2 ka event (Alley *et al* 1997; Alley & Ágústdóttir 2005) at *c*. 6200 cal BC, had widespread, hemispheric impacts, felt intensely at the latitude of Argyll (Seppa *et al* 2007) and involved a temperature depression in parts of the North Atlantic of 2-3ºC. North-west Europe was markedly more arid.
- From *c*. 4400 cal BC until *c*. 3800 cal BC a series of complex changes occurred at the Mesolithic-Neolithic transition (Bonsall *et al* 2002; Tipping 2010 but see Schulting 2012).
- Recent work has emphasised an event centred at *c*. 3200 cal BC (Roland *et al* 2015).
- Many diverse analyses identify the period 2200-1800 cal BC as one of abrupt global climate change (Mayewski *et al* 2004) though Swindles *et al* (2013) argue for its weak expression in the eastern North Atlantic region.
- The early Iron Age *c*. 800-500 cal BC, long seen as a period of marked climatic deterioration (Burgess 1985; Barber 1998; van Geel *et al* 1998; Charman 2010; Swindles *et al* 2013). Armit *et al* (2015) have recently questioned the impact of this event on societal change in Ireland.
- A 'Dark Age' climatic deterioration is recognised in some reconstructions centred on cal AD 500 (Swindles *et al* 2013)
- The 'little ice age' commenced at *c*. cal AD 1400 and ceased by *c*. cal AD 1850 and can be resolved as a series of short-lived climatic extremes.

**Coastal change**

**1. Holocene sea level change**

This topic can appear remote to archaeologists but in Argyll & Bute it is critical, not just to early prehistorians but to later prehistorians and early historians. Shennan *et al* (2006) published the first detailed reconstruction for the region, in Knapdale (Map 2). Their approach was to identify enclosed coastal basins at different altitudes and recognise the time they received estuarine and marine sediment from diatom and pollen analyses, and the time this sediment was replaced by terrestrial sediment (peat) as sea level fell.

Devensian Lateglacial sea level has been described above. Early Holocene shorelines will also have sloped because of differential uplift but we have few data points to reconstruct this gradient. Sea level is modelled to have fallen to -5m below present on Skye, to around 0m on Arisaig but to have remained above present tidal limits, around 2m above present in Knapdale (Shennan *et al* 2006) but empirical evidence for this at the sites analysed by Shennan *et al* (2006) is currently lacking. On Islay, Dawson, Dawson & Edwards (1998) date the lowest early Holocene RSL at around 0m OD to *c*. 9350 cal BC, as Dawson *et al* (2001) do on northern Coll.

Dawson *et al* (1998) then describe a rapid RSL rise on Islay to 3m OD by *c*. 7960 cal BC, slowing to *c*. 5m OD by the Neolithic period. On Oronsay, Jardine (1977) thought sea level reached *c*. 7m OD before this time. Sequences on the Scottish west coast currently lack the chronological precision to test the suggestion (Clarke *et al* 2003) that the collapse of the Laurentide ice sheet caused a nearly instantaneous global RSL rise of around 1.4m.

In Knapdale this shoreline, the Main Postglacial. Shoreline, reached *c*. 11m OD (Shennan *et al* 2006) and *c*. 10m OD on Arran (Gemmell 1973). Bonsall & Sutherland (1992) suggested that coast-facing caves in the Oban area occupied prior to the Main Postglacial Shoreline would have been eroded during RSL rise, thus seeming to shorten the duration of the 'Obanian' flint industry.

Dawson *et al* (1998) suggested that RSL levels remained high on Islay, above 4m OD until the late Iron Age, and a similar suggestion can be made for Coll (Dawson *et al* 2001) and, outside the region, for Skye (Selby 2004). This differs from the interpretation of Jardine (1977) on Oronsay for a 3m fall in the late prehistoric period and by Shennan *et al* (2006) in Knapdale who see RSL fall steadily *c*. 11m OD at *c*. 3500 cal BC to 3-4m OD by *c*. cal AD200. Smith *et al* (2007) construct a $^{14}$C-dated RSL curve for south west Scotland in which RSL continues to remain high (above 8m OD) until after *c*. 2000 cal BC. They try to resolve the different interpretations by identifying a narrow zone in south west Scotland where the Main Postglacial Shoreline converges with a later shoreline, the Blairdrummond Shoreline (Smith, Cullingford & Firth 2000), to maintain relatively high RSL, perhaps into the early historic period. This narrow zone crosses southern Kintyre and separates Islay from northern Kintyre, explaining the contrasts apparent in these two places (above), and straddles Mull (Smith *et al* 2007, fig. 8).

Reconstructing later prehistoric and early historic RSL change is thus a complex issue in Argyll & Bute, in which site-specific patterns override regional trends. Radiocarbon dates anywhere in the British Isles on RSL change post-2000 cal BC are rare (Shennan & Horton 2002) but a site like Barr na Criche in Knapdale demonstrates that detailed reconstructions in this period are possible. Sutherland (1997) drew attention to the rare large coastal sediment stores of mid- and later Holocene age where 'unpicking' post-Neolithic RSL change would be feasible. These include the Machrihanish and Moine Mhor embayments. No work at Machrihanish is known to this author. Analyses of RSL change in the Moine Mhor (Haggart & Sutherland 1992) remain skeletal but the potential is enormous because the base of the peat falls from *c*. 10m OD to *c*. 2m OD, implying that basal peat formed at progressively later times as RSL fell. We do not know if it was possible to sail to the foot of Dunadd in the early Historic period.

There have been very few attempts in the region to depict in map form how coastal areas will have altered with RSL change, although this could greatly aid archaeological understanding of site distributions in the way exemplified in the Forth valley by Smith *et al* (2010). Dawson *et al* (1998) described the physical isolation of the Rhinns of Islay from the east of the island as RSL rose in the early Holocene. In the Moine Mhor, Winterbottom & O'Shea (2002) looked at the effect of a 10.0m OD RSL on Neolithic and early Bronze Age archaeological site distributions to great effect.

## 2. Coastline and marine changes

By this is meant change to our coastlines other than directly by sea level change. It embraces evidence for past coastal erosion and deposition and evidence for the abundances in the past of marine and littoral resources. Such evidence is fundamental to understanding the archaeology of Argyll & Bute in several ways.

Perhaps the least important aspect to this is in measuring the rate at which current coastal erosion and storm damage impact on coastal sites (Dawson 2003). The 'soft' dune and machair coasts of the islands are most vulnerable. There are coastal zone archaeological surveys for Coll, Tiree and Islay and Shorewatch programmes on Coll and Islay (ScAPE Trust). There are no surveys, to the authors' knowledge, of the exposed western Kintyre coastline and the dune system around Machrihanish, or of sensitive salt marsh environments at the heads of the Kintyre fjords and the Moine Mhor.

We know very little from the region about the environmental changes at the coast or offshore. The evidence and potential are there, however. Gerard Bond pioneered such research in identifying transport from the Arctic Ocean of "armadas" of icebergs as far south as the Irish west coast periodically in the Holocene at *c*. 9200, 8300, 7400, 6200, 3900, 2200 cal BC and *c*. 600 cal AD (Bond *et al* 1997). Thornalley, Elderfield & McCave (2009) analysed fluctuating surface and deep-water temperature and salinity south of Iceland. Changes in either will have affected the abundance and locations of spawning and feeding grounds for fish populations. They recognise falling salinity from the start of the Holocene to *c*. 6000 cal BC: the 6200 cal BC event freshened by 0.4psu the North Atlantic. Sea water was well mixed and fresh after this event for *c*. 1000 cal years until *c*. 5000 calBC. Salinity then increased to present values at *c*. 3000 cal BC. Rapid freshening set in after *c*. 2000 cal BC until this trend was reversed at *c*. 1400 cal BC. Particularly warm and saline conditions occurred at *c*. 3000 and 700 cal BC and at *c*. cal AD1000, probably representing persistent westerly winds at these times. Marret, Scourse & Austin 2004) have described major changes to thermal stratification in the Celtic Sea between Ireland and Wales, with strong contrasts in seasonality inferred for the period *c*. 4700 to *c*. 1650 cal BC. In the sediments of Loch Sunart, Cage & Austin (2010) define with clarity the switch from the medieval 'warm' period to the 'little ice age' at *c*. AD1400. Annually and seasonally resolved climate signals from marine molluscs are being explored (Stott *et al* 2010; Wang, Surge & Mithen 2012).

Sand dune accumulation is a major information source. This is no longer seen to be a product of sea level change but as a product of abrupt climate change, and increased storminess in particular (Bjorck & Clemmensen 2004; Clarke & Rendell 2006; De Jong *et al* 2006; Orme, Davies & Duller 2015), so here we have a measure of sea conditions that were perhaps unpredictable enough to deter crossings. Dunes on the Outer Isles (Gilbertson *et al* 1999; Dawson *et al* 2004), in Wester Ross (Wilson 2002) and along the north Irish coast (Wilson, McGourty & Bateman 2004) have been analysed. There is periodicity rather than continuity in dune and *machair* accumulation, with phases of dune building *c*. 4300-3800, 3200, 280-2400, 1400-1200 and 800-300 cal BC, and cal AD850 and 1400-1800. But dating by $^{14}C$ is restricted to periods of climatic stability and by optically stimulated luminescence untried on the west coast compared to their deployment on the north Scottish coast (Sommerville *et al* 2003, 2007; Tisdall *et al* 2013).

Winterbottom & Dawson (2005) attempted to locate archaeological structures buried by drifting sand on Coll by remote sensing and ground penetrating radar, as Astin has with Mithen (Mithen pers. comm.) but the recovery of archaeological remains from dune systems will always lead to partial chronologies of dune formation. Systematic dating programmes are badly needed.

Sediment-stratigraphic and biological RSL indicators tend to describe mean sea levels, not tidal or wave extremes. Jardine (1987) mapped a series of storm-beach gravel ridges on Oronsay, thought to be of mid-Holocene age, one at least perhaps 10m above contemporary mean sea level. Smith *et al* (2007) surveyed storm beach ridges probably dating to the mid-Holocene on the west and east coasts of Bute which reached up to 3m higher than contemporary mean sea level. The probable Mesolithic site of Croig on Mull is protected by a large storm beach (Mithen pers. comm.) as is the Mesolithic site of Kilmore near Oban (Macklin *et al* 2000). Early Holocene storm beaches are deposited from a significantly lower sea level, of course. These kinds of observation are rare: there need to be more. Systematic mapping and dating of storm beaches would provide data, though biased to Devensian Lateglacial and post-4000 cal BC events, to infer past periods of increased storminess, the degree of exposure of particular parts of the coast and the modelling of wave extremes that may have been critical to travel by sea. Innovative approaches such as Andrews *et al*'s (1987a) estimation of later Mesolithic storminess from dogwhelks is to be encouraged. These authors suggest the later Mesolithic to have been less stormy than today.

There is no substantiated method other than from archaeological analysis (Barrett, Nicholson & Ceron-Cerrasco 1999) for defining the presence or size of fish populations in near-shore or deep waters (Pickard & Bonsall 2004) but such analyses are bound to reveal more about food selection than availability and abundance. The same is true of analysis of marine shells (Connock, Finlayson & Mills 1992). Sediment-stratigraphic methods need to be developed, perhaps biochemically or from quantification of fish scales (Davidson *et al* 2003) to define the natural abundance of marine resources and their availability.

## Terrestrial change

### 1. Geomorphological change

Map 3 shows the localities where something is known of physical changes in the Holocene to the landscape of Argyll & Bute: the number is distressingly small. We can divide this collection into analyses of colluviation (slope and soil erosion and subsequent re-deposition) and alluviation (fluvial erosion and deposition). The two can be closely linked.

*Colluvial activity*

Tipping *et al* (2011) obtained perhaps the most securely dated record of slope and soil erosion in Scotland at Torbhlaren in the lower Add valley. Peat forming on the valley-side above the floodplain received varying amounts of soil eroded from sandy glacio-marine terraces above. An alluvial fan on the slope began to form from *c*. 7500 cal BC and in one colluvial record, colluviation also commenced within the Mesolithic period, at *c*. 5110 cal BC. Despite being only a couple of hundred metres apart, the three dated sediment cores suggest that the phases of most intense soil erosion were diachronous. Sediment delivered at high energies to one borehole between *c*. 4800 and *c*. 4250 cal BC has no counterpart in an adjacent borehole, though comparable high-energy events might be recorded in both at *c*. 3800-*c*. 3200 cal BC and *c*. 3550 and *c*. 3400 cal BC. Further high-energy mineral sediment movement ocurred between *c*. 200 cal BC and *c*. cal AD 50 and after *c*. cal AD 700.

In the Oban region, Rhodes, Rumsby & Macklin (1992) and Macklin *et al* (2000) analysed soil erosion from geochemical signals. Rhodes *et al* (1992) report analyses for a range of elements at Gallanech Beg but with no discussion of the data while Macklin *et al* (2000) report only potassium (K) in three additional peat sequences at Lon Mor, Bhuilgh bhith and Cnoc Philip. They argue that soil erosion was greatest in the transition to farming between *c*. 3500 and *c*. 2000 BC, but also in the same paragraph argue for soil stability between *c*. 3600 and *c*. 2000 cal BC. Finally, Cressey (unpublished) used geochemical signatures to trace the development of a medieval landscape at Lochs Finlaggan and Ballygrant on Islay.

In upper Glen Etive, the Dalness Chasm debris cone, a large fan-shaped sediment pile formed from eroded material high above, formed between earliest Holocene deglaciation and c. 2200 cal BC. Around cal AD 1600 the clearance of hazel scrub by people, including by fire, is thought to have re-activated the lower slope of the fan by fluvial erosion (Brazier, Ballantyne & Whittington 1988) though the date of this reworking is coincident at least with the 'little ice age' (Ballantyne 1991). Innes (1983) argued that over-grazing of upland slopes since the later 18$^{th}$ century greatly increased talus and debris cone formation.

*Fluvial activity*

In Loch Etive itself, Howe *et al* (2002) described how terrestrial sediment sources have dominated sedimentation in this sea loch throughout the Holocene, with accelerating sediment accumulation rates in the last *c*. 200 years originating, probably, from changing land use from, for instance, woodland management for the iron-smelting industry.

In and near Kilmartin Glen, Tipping *et al* (2011) described Neolithic and Bronze Age river development and channel change in the lower River Add at Torbhlaren. There was increased flood frequency/magnitude at around 2400 cal BC and major changes in river behaviour at *c*. 1240 cal BC but unchanging channel dimensions through the Holocene suggest that discharge did not significantly vary.

To the west, Housley and co-authors $^{14}$C dated one of many peat-filled abandoned channels of the lower Add near Dunadd to the BC-AD boundary. No significance can be attached to this age estimate, though, without also dating other channels. The peat filling this channel was terrestrial (Miller & Ramsay 2001; Housley *et al* 2004; Housley *et al* 2010). It would be interesting to know the altitude of this channel in light of the discussion on early historic RSL change (above) but this is not given.

Carter & Tipping (1991-2) and Tipping, Carter & Haggart (1994) mapped the terrace surfaces along the lower Carra Water on Kintyre. Most are related to glacial or relative sea level stages but the extensive Rhonadale Wood Terrace is fluvial. It began to accumulate between 4500 and 3500 cal BC when sufficient sediment from earlier-formed terrace fills or soils on slopes filled the river enough to promote frequent flooding and the creation of a floodplain.

Its surface was abandoned by the river as it incised at some time in the last few hundred years.

These isolated reports are not nearly enough to write an informed history of landscape change. There is, perhaps, the suggestion that Neolithic colluviation and alluviation were significant, and this would be different to other regions of the British Isles but the evidence is limited. The region needs such a history because changes in human settlement and land uses are implied in the interpretations of some of these physical changes although abrupt climate change provides an additional strong hypothesis. It is very likely that geomorphic changes in the highlands and on steep slopes such as debris cone formation were climatic in origin (Ballantyne 2004) because pastoralism is likely to have made few impacts, but colluviation in lowland valleys as at Torbhlaren need not have been. Yet here Mesolithic and Neolithic colluviation occurred in the absence of evidence for major human activities in the pollen record (Tipping *et al* 2011). The prevailing paradigm in Holocene alluviation in the British Isles is also for a climatic causation (Macklin, Johnstone & Lewin 2005) but many case studies do not explore the timing or scale of human activities, biasing somewhat the conclusions. Where both hypotheses are equally appraised, human activity emerges as important. Argyll & Bute should provide an important testing ground for this debate.

## 2. Pedological change (Map 4)

There were three archaeological sites known to Donald Davidson and Stephen Carter in 1997 that allowed some assessment of soil type and land use quality in the past: An Sithean on Islay (Barber & Brown 1984), Cul a' Bhaile on Jura (Stevenson 1984; Whittington 1988) and at Achnacree (Soulsby 1976; Carter & Dalland 2005). At all three, soils had become acid podsols by the Bronze Age. Impoverished soils were probably the norm in Argyll & Bute in later prehistory. Nevertheless, An Sithean and Achnacree contain two of the best-explored later prehistoric field systems in Scotland, though at An Sithean the system is less coherent than first appears (Barber & Brown 1984; Halliday 2015, 284). Beneath the Caisteal nan Gillean II shell midden on Oronsay, the soil was also acid and leached (Paul 1987). Barber (1981) argued that soils at the monastery of Iona were anthropic plaggen soils, a deliberate introduction as agricultural improvement: it would be good to test this idea further.

The Moine Mhor is a raised moss, formed on an impermeable substrate of marine clay following mid-Holocene sea level fall, probably over a very long time (above). Such mosses spread laterally: the Moine Mhor at its fullest might have covered 1800 ha compared to 1200 ha today. The archaeological potential beneath the moss remains undiscovered despite ground penetrating radar survey (Housley, Clarke & Campbell 2007).

The blanket peat cover at Achnacree has been $^{14}$C dated, though poorly (Carter & Dalland 2005), to between *c*. 1550 cal BC and *c*. cal AD 250. The moss has formed on well drained glaciofluvial sands and gravel, so that a palaeo-hydrological signal for peat inception must be suspected, somewhat obfuscated by the great range of the available calibrated $^{14}$C assays. The Moss of Achnacree remains one of the most significant later prehistoric archaeological landscapes in the British Isles: its paleo-environmental potential has only inadequately been explored despite the attentions over several decades of many leading archaeologists (see Carter & Dalland 2005). The glaciofluvial sand and gravels are studded with kettle holes, some large but many small, basins containing complete Holocene sediment records which are key. Carter & Dalland (2005) rightly indicate that we would now have less confidence in the stratigraphic integrity of pollen within soils. The small-diameter kettle holes must record, free of disturbance, pollen-analytical data on later prehistoric agricultural activities. Attention has focused on the Bronze Age field system/s at Achnacree, but the kettle holes must also contain a record of the earliest agriculture on substrates known elsewhere to have attracted early Neolithic agriculture (Fairweather & Ralston 1973; Murray *et al* 2010), very close to the chambered cairn at Achnacreebeag (Ritchie 1970) which plays such a significant role in Alison Sheridan's (2007, 2010) chronology of earliest Neolithic introductions.

Blanket peat is not common in Argyll & Bute, but the region has peaty gleys in abundance because of a clay-rich till (boulder clay), extensive poorly drained plateaux and a wet climate. Nothing is known of their development but they represent a major impediment to agricultural potential. It is important to understand the timing of this critical pedological change in the region and its relation to climate change and human activities.

## 3. Vegetation change in the Mesolithic period

Map 5 shows the distribution of pollen sites known to the author that describe Mesolithic-age plant communities in the region: in the absence at a number of sites of detailed $^{14}$C-derived chronologies this estimate  is based on the rise of *Alnus* (alder) pollen but the absence of an *Ulmus* (elm) decline. They are abundant: this is probably the densest array of such sites in Scotland. Those by Durno with Mercer on Jura and are of historical interest only (Edwards 2000) but many analyses are cutting-edge. Most of these are uniformly of high quality with regard to pollen taxonomy and temporal resolution, though in many there was no recording of microscopic charcoal. Most are 'sensitive' sites, describing plant communities and their changes at spatial scales small enough to identify and be supportive of archaeological evidence for similarly small-scale human activities.

The majority have not been analysed to explore anthropogenic activities, however. Some sites extend analyses of Devensian Lateglacial sediment into the early Holocene (Map 1: above). Others were constructed to understand the dynamics of deglaciation of ice sheets and valley glaciers of Loch Lomond Stadial age. Those along Loch Awe at Ford, Inverliever and Barachander (Tipping 1987, 1988, 1989a) and in Cowal at Na Lona Min (Tipping 1986) do not extend to sediments younger than *c*. 9000 cal BC. However, those on Rannoch Moor at Clashgour, Corrour, Kingshouse and Rannoch Station (Walker & Lowe 1977, 1979, 1981, 1985, 1987), on Loch Linnhe at Lairigmor (Walker & Lowe 1981) and on Mull at Coire Clachach, Fhuaran, Gribun and Torness (Lowe & Walker 1986) describe plant communities for the bulk of the Mesolithic period. None of these sites have records of microscopic charcoal.

Holocene vegetation histories at Lochan Taynish (Rymer 1974) and Cill an' Aonghais, both in Kintyre (Peglar 1980), in Loch Lomond (Dickson, Jardine & Price 1976) and on the east bank of Loch Lomond at Dubh Lochan (Stewart, Walker & Dickson 1984) are constructed by applying a uniform sampling interval, not specifically looking for or exploring in detail human activities but noting them when recorded. Their locations may in turn not be optimal for the archaeological record. Peglar's record has not been published: it is available only in a field guide which has almost no interpretation. The Loch Lomond record lacks detail.

A cluster of pollen sites on Islay were analysed to understand Mesolithic vegetation history and human disturbance to plant communities (Mithen 2000) including Coulerach (Bunting *et al* 2000), Bealach Froige, Cultoon, Gruinart, Loch Gorm and Sorn Valley (Edwards 2000) and Loch a'Bhogaidh (Edwards & Berridge 1994; Edwards & Mithen 1995). Analyses at Loch Cholla, Colonsay were intended to understand the Oronsay shell middens excavated by Mellars (Andrews *et al* 1987b). On Coll, the site of Loch an-t Sagairt is as yet unpublished (Wicks & Mithen 2013). Edwards, Langdon & Sugden (2007) tried to disentangle anthropogenic from climatic effects on the vegetation at Loch an't Suidhe on Mull around *c*. 6200 cal BC. The site of Rhoin Farm, west of Campbeltown, was analysed by Edwards & Mackintosh (1988; Edwards 1990) to explore pre-elm decline agricultural activity.

Four pollen sites are included in Macklin *et al*'s (2000) paper on the Oban region. These are very problematic. The full data-set is found in Fay Davies's (1997) PhD thesis. The pollen sum (the basis for all percentage calculations) is unconventional in that it includes spores and pollen of aquatic plants. This renders the pollen diagrams hard to compare with others and difficult to interpret. Interpretation requires the full data-set but Macklin *et al* (2000) present summaries only, of all trees and shrubs, Gramineae, cereal-type pollen and *Plantago major*, together with concentrations of microscopic charcoal (their fig. 3). Grouping all trees and shrubs together is too simplistic an approach to describing woodland loss. Choosing *P. major* to describe pastoral activities is odd: *P. lanceolata* is the accepted indicator. These choices make these pollen records far less than the corner-stone of future work they should be. No details of how the chronologies for the pollen diagrams were constructed is given by Macklin *et al* (2000): construction appears not to have been straightforward (Davies 1997). The discussion by Macklin *et al* (2000) is synthetic from the start, lacks detail as a result and is too concise.

The difficulties of defining an unambiguous hunter-gatherer signal in pollen records are many, not least because new data on the intensity of abrupt climate change introduce mechanisms by which vegetation can be naturally disturbed. Tipping (1996) argued, for instance, that relative drought increased the likelihood of wildfires in northern Scotland, contested by Bishop, Church & Rowley-Conwy (2015) though true at the global scale (Carcaillet *et al* 2002). Random events like lightning-strike fires and tree-felling in storms (e.g. Tipping (2008) at Clashgour on Rannoch Moor) are feasible sources of woodland change. Edwards *et al* (2007) elegantly evaluated human-climate agencies at Loch an't Suidhe on Mull across the major early Holocene abrupt climate change event at *c*. 6200 cal BC. Losses of deciduous woodland around 6300 cal BC are accompanied by increases in microscopic charcoal, which were argued to have been anthropogenic in origin because climatic deterioration was recorded from chironomid analyses after, not during woodland loss. Errors in $^{14}C$ dating may explain why the climatic deterioration appears not to be that at *c*. 6200 cal BC (though see Edwards *et al* 2007 for other interpretations) but do not detract from their more general conclusions.

On Islay, Mesolithic anthropogenic activity has been suggested from closely-spaced pollen analyses seeming to describe short-lived vegetation disturbance, accompanied by burning (Edwards 2000). Events are diachronous across the island, which Edwards (2000) uses to dismiss climatic causation. Disturbance was particularly widespread in the 6$^{th}$ millennium BC. The astonishing find of burnt hazel nuts – the product of perhaps some 15000 trees – at Staosnaig on Colonsay (Mithen & Finlayson 1991) excited much interest, with the suggestion that the pollen record might be able to detect this event (Edwards 2000) but the key factor for the human community on Colonsay would have been the sustainability of the resource through management. We cannot currently demonstrate woodland management from pollen data with conviction (Waller, Grant & Bunting 2012), but tree-ring data from hazel stems can suggest coppicing cycles. Such evidence needs to be sought. Andrews (in McCullagh 1989) also identified possible anthropogenic woodland disturbance on Islay, around the Sorn Valley, around 5900 cal BC. In the Oban area significant woodland loss, associated with burning, is also recorded for short time intervals throughout the Mesolithic.

Anthropogenic signals in the Mesolithic were not recorded at any of their fourteen sites by Lowe & Walker (1986: Walker & Lowe 1977, 1979, 1981, 1985, 1987). This may in part be because microscopic charcoal was not recorded by them, or because the time interval between pollen samples was too coarse, but this is an intriguing if negative result. Andrews *et al* (1987b) also did not report Mesolithic-age anthropogenic impacts on Colonsay though the sampling interval is comparatively coarse and microscopic charcoal not recorded. Tree pollen rarely exceeds 20% total pollen and spores in the diagram, though, and the landscape must have been quite open, maintained by a high degree of exposure to winds. Walker & Lowe (1985) also infer a high degree of exposure to wind from the low representation of trees at sites on Mull, and around Iona Loch the dominant vegetation in the Mesolithic is a grass-heath with few trees (Scaife & Dimbleby 1990). It is difficult to see in these open settings why people would have needed to disturb woodland: models for anthropogenic interference derived from the closed deciduous woodlands of eastern England (Simmons 1996) need not have applied to the Scottish west coast. Other landscapes appear more wooded, but nevertheless the precise 'ecology' of these disturbances in western Scotland, and if purposeful what they achieved, needs to be explored much more fully. This is now a pressing need because if anthropogenic signals in Mesolithic-age pollen records along the Scottish west coast can be demonstrated, the technique is one of the few that could test Wicks & Mithen's (2013) suggestion of population collapse in and after the 6200 cal BC abrupt climate change.

The possibility that Mesolithic people might have precociously planted cereal crops was for a time an intriguing idea (Edwards 1989; Edwards & Hirons 1984). Macklin *et al* (2000) report cereal-type pollen as early as *c*. 9250 cal BC at Gallanach Beg but interpret them as deriving from wild grasses. The site at Rhoin Farm was analysed (Edwards & Mackintosh 1988) to test this by scanning for cereal type pollen for much longer than normal in pollen counts. Cereal type pollen in pre-elm decline contexts was found, but was not shown unambiguously to be from cereal grasses: almost all the pollen grains are of *Hordeum* type (barley type), which includes many wild grasses known to produce cereal-size pollen it habitats such as the sand dunes that surround the site today and probably also in prehistory.

## 4. Vegetation change and land uses in later prehistory and the historic period

Map 6 shows the locations of pollen sites in Argyll & Bute that cover all or some of the period from *c*. 4000 cal BC to the present or close to it. The current data-set for this long period fragments when the times the pollen records span and their purposes are described. The sites on Mull at Gribun (Walker & Lowe 1987), Fhuaran and Torness (Walker & Lowe 1985), Loch Cill an Aonghais (Peglar 1980), Loch Lomond (Dickson *et al* 1976), and Clashgour and Coire Seilich on Rannoch Moor (Bridge *et al* 1990) are vegetation histories (see Section 3) rather than land use histories but the long records at Loch Cholla (Andrews *et al* 1987b), Loch a'Bhogaidh (Edwards & Berridge 1994), Dubh Lochan (Stewart *et al* 1984) and the four sites in and around Oban presented by Macklin *et al* (2000) were intended to have human activities as their investigative focus.

Hale's pollen analyses at Glengorm on Mull (in Martlew & Ruggles 1996) were designed to throw light on inter-visibility from standing stones and rows, but the data were not dated or presented, only discussed, and the pollen record itself (Hale pers. comm.) is considered by this author not to relate in time to the monuments. The sites of Cairnbaan and Glasvaar in and near Kilmartin (Long 2002; Winterbottom & Long 2006) and at Torbhlaren (Tipping *et al* 2011) were analysed to understand the landscape contexts of later prehistoric rock art sites. The first two are undated. Analyses at Dunadd (Miller & Ramsay 2001; Housley *et al* 2004; Housley *et al* 2010) commence in the later Iron Age and explore land use change around the fort in the early historic and medieval periods. Iona in the early historic period has unsurprisingly attracted much palynological interest (Bohncke in Barber 1981; Balaam in Reece 1981; Scaife & Dimbleby 1990; Tipping in McCormick 1993) but has generally disappointed. Small 'snapshots' in time were generated by Balaam, Bohncke and Tipping and although Scaife & Dimbleby (1990) argued that the sediments in Iona Loch are a complete Holocene record, this is very unlikely, and peat cutting is suggested here to have truncated the stratigraphy above the later prehistoric period. At the head of Loch Awe is a concentration of analyses that have recently specifically explored medieval and later land uses (Sansum 2004; Davies & Watson 2007).

Macklin *et al* (2000, 113) described "substantial deforestation" from *c*. 4300 cal BC at some sites, but in detail (Davies 1997) the losses are often seen to be of wetland trees and need not have been anthropogenic. 'Clearance' around Cnoc Philip at *c*. 2000 cal BC is from the expansion of ling heather (*Calluna*) and, probably, blanket peat (Davies 1997) and again need not have been anthropogenic, which perhaps challenges the suggestion of widespread synchroneity around Oban of "more settled farming practices" in the early Bronze Age (Macklin *et al* 2000). The suggested correspondence between later prehistoric phases of farming with climatic change is exciting but rests on absences of cereal type pollen, which is always under-represented in pollen records.

*Neolithic activity*

Whitehouse *et al* (2013) have recently argued for the begining of the Irish Neolithic at *c*. 3750 cal BC. Around Coire Clachach in central Mull (Walker & Lowe 1985), *Plantago lanceolata* appears in the early Neolithic at *c*. 3850 cal BC, and some dryland trees like hazel and oak began to be lost. This pattern is described from Loch a'Bhogaidh on Islay from this date (Edwards & Berridge 1994) and from the Sorn Valley (Andrews in McCullagh 1989) from *c*. 3750 cal BC, though at the latter site by a single pollen grain only. At Gribun on the exposed west coast of Mull a plant community with wild grasses was established before the elm decline, further increasing from *c*. 2850 cal BC as the birch population fell (Walker &

Lowe 1987). Losses in hazel and an expansion of grassland with *P. lanceolata* occurred prior to the elm decline around Iona Loch, and cereal type pollen is recorded from the elm decline (Scaife & Dimbleby 1990). Also on Iona, Bohncke (in Barber 1981) suggested Neolithic farming included cereal crops. Near Kilmartin, valley-floor woods at Torbhlaren were partly cleared from as early as *c*. 4300 cal BC (Tipping *et al* 2011), with regeneration between *c*. 3200 and *c*. 2900 cal BC. Cereal cultivation was introduced at *c*. 3300 cal BC. Tipping *et al* (2011) suggested that at *c*. 2900 cal BC oak woodland began to be conserved, or perhaps planted, and grown on for some 800 cal years until the woodland was abruptly felled at *c*. 2100 cal BC. This activity may have coincided with the creation of rock art on the valley floor. At Lochan Taynish, Rymer (1974) reported only limited woodland disturbance in the Neolithic, after *c*. 3400 cal BC. Close by at Loch Cill an Aonghais (Peglar 1980), whilst *P. lanceolata* appeared at the elm decline, grassland expanded only from *c*. 3400 cal BC. In the Sorn Valley, grassland with *P. lanceolata* was established around 3100 cal BC (Andrews in McCullagh 1991).

Long's (2002; Winterbottom & Long 2006) reconstructions of the local landscapes around the rock art panels at Cairnbaan and Galsvaar (Map 5) suffer from the absence of dating controls. Elm declines are recognised at both pollen sites but at the boundary between mineral soil and overlying peat, so that it is unclear whether the decline is real or is a taphonomic effect: these sites need to be re-visited and $^{14}$C dated.

*Bronze Age activity*

On Mull at Torness, *P. lanceolata* appears from *c*. 2500 cal BC and a large expansion of grasses is recorded from *c*. 2000 cal BC with falls in hazel. At Fhuaran a sharp fall in oak pollen proportions at *c*. 2000 cal BC coincides with a rise in those of wild grasses, with *P. lanceolata* consistently recorded after *c*. 1500 cal BC with a sustained decline of birch, oak and alder. At Gribun *P. lanceolata* was established from *c*. 2000 cal BC in a landscape of grass and heath (Walker & Lowe 1987). Andrews *et al* (1987b) described a grazed grassland with P. *lanceolata* established around Loch Cholla on Colonsay from *c*. 2650 cal BC and around An t-Aoradh on Oronsay after *c*. 1700 cal BC. It is possible that arable activity is recorded from *c*. 1900 cal BC around Loch Cholla. Cereal type pollen is also found from *c*. 2000 cal BC on Islay, around Loch a'Bhogaidh (Edwards & Berridge 1994) with an expansion in grazed grassland. The Dubh Lochan record (Stewart *et al* 1984) differs from those in the west of the region in showing negligible woodland clearance until the later Bronze Age at around 1100 cal BC, and little further change.

*Iron Age activity*

Andrews *et al* (1987b) saw birch wood regeneration from *c*. 800 cal BC to *c*. 570 cal BC on Colonsay as indicating reduced human activities. After *c*. 500 cal BC, however, came further woodland clearance and the emergence of a treeless landscape. On Kintyre a loss of hazel woodland in the region is recorded from Taynish Fen by Rymer (1974) after *c*. 500 cal BC, more sustained after the BC-AD boundary. Losses of oak and alder woodland occurred around Loch Cill an Aonghais at this time (Peglar 1980). Around Gribun on Mull the alder and hazel woodlands collapsed at *c*. cal AD 150 (Walker & Lowe 1987).

*The historic period*

Grassland around Dunadd was common at the BC-AD boundary. Locally, proportions of wet woodland declined at *c*. cal AD 400 and those of dry woodland declined *c*. cal AD 650. Heathland was established locally *c*. cal AD 450 but in the region only after *c*. cal AD 1100. A peak in the proportions of birch is seen immediately following abandonment of Dunadd *c*. cal AD 900, though later medieval woodland clearance removed it (Miller & Ramsay 2001). The Dunadd record has its interpretative problems in that the pollen signal seems somehow muted, not what you expect around such a site, and maybe the abandoned channel lay at the time within a larger Moine Mhor, distant from fields. There are other major, perhaps more significant citadel forts than Dunadd in the region such as Dunagoil on Bute (Harding 2004, 141-4) with peat close by which would reward investigation.

Bohncke (in Barber 1981) presented pollen data from Iona Fosse, $^{14}C$ dated to around cal AD600. These have always perplexed in their interpretation of ash and oak woodland around the monastery when the ditch began to infill, not found by either Balaam (in Reece 1981) and Tipping (in McCormick 1993), who both sampled for pollen analyses a peat buried beneath the bank of the inner vallum of the monastery, pre-dating monastic colonisation by 300-500 years. It is simplest to assume that the tree pollen in Bohncke's record pre-dated any early historic period. Even so, ash-oak woodland would be unusual on the west coast and Bohncke's pollen spectra might be distorted by taphonomic processes. Balaam's and Tipping's samples came from different parts of the same bank, it is thought, and in detail they do not correlate (Tipping in McCormick 1993) but broadly it can be suggested that an open woodland of, probably, hazel was lost as *Calluna* heath expanded, and this was then succeeded by grazed grassland, but no record of other agricultural activities could be recognised. Ditch I stood next to a hedge of elder (Bohncke in Barber 1981). It is doubtful if new sediment stratigraphies will be found on Iona. Kingarth on Bute (Laing, Laing and Longley 1998) is almost surrounded by peat bogs. Lismore in the early historic period is yet to be understood fully. And what human activities might we expect around Eigg's monastic settlement with its links to the ascetic Céli Dé movement, the "desert isle in the ocean" (Fraser 2009, 370).

The transformation of the diverse landscapes around Oban from wooded to largely treeless was a product of clearance in a couple of hundred years after *c*. cal AD 850 (Macklin *et al* 2000). Though the pollen data for the eastern Loch Lomond oakwoods (Stewart *et al* 1984) reveal no evidence for intense woodland management in the last several centuries identified by Lindsay (1975) from the documentary record, Sansum (2004) profitably explored both in establishing the history over the last millennium of semi-natural western oakwoods at sites at the head of Loch Awe (Map 6), emphasising 18$^{th}$ and 19$^{th}$ century management of oak and hazel for commercial ventures. In the same area, Davies & Watson (2007) used both data sources to explore over the last *c*. 400 years the management of hill pastures and upland woods. Both studies employed what are known as 'small hollows', peat in basins small enough you can almost hop over, which describe the close details of a taskscape.

These brief descriptions of the results of many pollen analyses in the region might be seen as poor reflections of the interpretations but in most instances they are often not: they are what we have. It is not unsurprising in research strategies to see more data demanded but this simple observation is true for Argyll & Bute. The historic period in Argyll & Bute has been poorly served until very recently. In part this is because the establishment of organised agrarian landscapes in the last *c*. 1500 years has led to an apparent lack of landscape change. There is perhaps little for the pollen analyst to be interested in even though the demonstration of prolonged agricultural stability is often very significant to the archaeologist.

Pollen records like those on Mull and Rannoch Moor are from locations far from population centres. It is difficult, for example, to extract information on human activities from the sites on Rannoch Moor analysed by Bridge *et al* (1990), partly because only partial pollen diagrams showing only major pollen taxa were presented, but also because the landscape was probably devoid of human occupation for long periods. It is useful to understand land uses at the margins of occupation, although we tend to interpret these as extensions of core activities, like mixed farming, simply expanding onto more intractable soils and climates. We are not good at identifying in the pollen record distinctive locale-specific activities such as shieling that may explain why people were in such seemingly marginal settings.

We have not investigated critical landscapes like Kilmartin (Sheridan 2012) or, in any depth, Achnacree (Carter & Dalland 2005). There is no clear understanding of the landscape settings of later prehistoric 'ritual' sites like Ruggles' corpus on Mull (Ruggles, Martlew & Hinge 1991; Ruggles & Martlew 1992; Martlew and Ruggles 1996) despite flawed attempts (Hale in Martlew & Ruggles 1996). Proving that trees were not blocking the view between a monument and what was to be looked at will be difficult but is feasible: intervisibility is a fundamental but un-tested assumption in archaeology (Fisher *et al* 1997; Cummings & Whittle 2003; Gibson 2004). Later prehistoric 'ritual' landscapes, if they existed, must have been managed or monuments would have been lost within regenerating woodland. Perhaps they were inside woodland: we should not think that the dynamic early Bronze Age agrarian landscape at Torbhlaren (Tipping *et al* 2011) tells us anything about Kilmartin: Torbhlaren is still marginal to this.

Only in recent decades have we come to ask questions of direct archaeological significance, working where the archaeologist is working, as at Glengorm in Mull, on Iona, however frustratingly short of information these data are, and at Dunadd and Torbhlaren. The idea at Dunadd was excellent: what impact did the precisely-dated rise to regional dominance of the fort have on local livelihoods? We need many more data in this critical period for Argyll. We can barely put together a coherent narrative for later periods. Did the transfer of power away from Dunadd have significance for the regional economy? What is the meaning of the regeneration of birch trees at Dunadd *c*. cal AD 900?

## Recommendations

1. It seems to this author that Argyll & Bute is very well placed to take a lead role in relating its archaeology to the sea. In Argyll "we can sense the presence of the sea", Whittow said in his *Geology and Scenery in Scotland* (1977, 194). The development of a sophisticated multi-

disciplinary research programme in Argyll on the significance of the sea to the archaeology of Scotland and north west Europe would be a great achievement. The Irish Sea is fundamental to any understanding of Scottish archaeology in any period. More than elsewhere in Scotland, the sea has connected people within Argyll & Bute and in the wider region. From the Mesolithic dispersal across the Inner Hebrides of Rhum bloodstone (Wickham-Jones 2005) and in the earliest Neolithic of Arran pitchstone across Scotland (Ballin & Faithfull 2009) we are accustomed to thinking of coastal travel between mainland and islands and the sea in general as a benign way of facilitating linkages between people. This is wrong for parts of the past. The sea can separate and isolate communities and perhaps not only for short periods.

There is the need to recognise that in the long term the sea and the marine environment have changed in ways we are only coming to realise. Callaghan & Scarre (2009), for example, calculated the journey times by sea from Brittany to Ireland and on to western Scotland in the early Neolithic as if weather, seas and tides were as they are now: they weren't.

The principal driver in such change is the complex interaction of marine currents and gyres in the North Atlantic Ocean that, simplistically, we call the "gulf stream". This transports warm water poleward, of course. It is far from stable. Empirical and modelling experiments have shown the fragility of this system to internal and external stresses. It is thought to have stopped functioning during the Loch Lomond Stadial and may have stopped at times in the Holocene (see Tipping *et al* 2013). A product of these is rapid or abrupt climate change.

Tipping (2010) took the Mesolithic-Neolithic transition in the British Isles as an example of the types of coastal change we might expect during this and other periods of abrupt climatic change. We can observe between *c*. 4000-3000 cal BC major changes in North Atlantic ocean circulation, significant fluctuations in salinity, much lower sea surface and deeper water temperature profiles, the dispersal of 'armadas' of icebergs as far south as western Ireland and increased precipitation which accelerated the input to the Arctic Ocean of fresh water, thus slowing the 'gulf stream' further. Under certain conditions, westerly wind speeds would increase in strength and frequency and wave heights in the eastern North Atlantic would increase. We would expect these changes to have induced very significant changes in the abundance and distribution of coastal sediment, coastal settlement and the abundance, spatial and temporal patterning of marine and littoral resources. At the Mesolithic-Neolithic transition, people that lived by the coast in Argyll appear to have 'slighted' the sea, turning from marine food resources (Schulting 1998; Schulting & Richards 2002). Were these resources lost from our coast through climatic deterioration? Schulting (1998, 214) considered this but through falling sea level, which is surely the wrong mechanism.

Argyll & Bute sits at the centre of a whole web of inter-connecting evidential strands to do with people and the sea. The laboratories of the Scottish Association for Marine Studies (SAMS) outside Oban would be very significant in this. The region has more key coastal and marine heritage sites than elsewhere in Scotland (Baxter *et al* 2011, 157). And it has Scotland's most extensive Marine Protected Area from Loch Sunart to the Sound of Jura.

2. There is a need in Argyll & Bute as elsewhere for archaeologists and natural scientists to exchange data and swap ideas.

3. Scattered throughout the text above, suggestions for further research have been made. This section brings those together but arranges them in chronological order:

1. We need empirical evidence for modelled low relative sea level stands in the region between the Loch Lomond Stadial and the mid-Holocene
2. There is an urgent need to establish securely dated early Holocene relative sea level rise to establish the 1.4m jump in the surface of the eastern Atlantic at *c*. 6200 cal BC
3. The work on Mesolithic-age human disturbance of plant communities in the region has been a sustained and major contribution at an international level. However, such disturbances are far from unambiguously recognised and there are now more alternative hypotheses to explain them by natural means. One advance would be a careful assessment of the ecological processes involved in these small-scale events, and a more critical testing of models of human impact 'imported' from environments unlike the west coast of Scotland. The significance of this work would be enormous because these disturbances, if clearly defined, offer one of the few tests of the post-6200 cal BC population collapse hypothesis of Wicks & Mithen (2013)
4. We need a systematic programme of mapping and dating storm-beach ridges along the Argyll coast (Bute has one: Smith *et al* 2007). These appear to have been *foci* of Mesolithic occupation. They would provide data on past storminess

5. The “slighting of the sea” is one of the most significant recent interpretations of social and economic change at the Mesolithic-Neolithic transition. We need fine-grained, highly resolved records of the changing abundances of marine resources through time from marine sediment archives
6. We know nothing about one of the most important assemblages of later prehistoric monuments in north west Europe at Kilmartin: this is criminal
7. Renewed archaeological and palaeo-ecological work on the Moss of Achnacree must be pursued because of the significance, first, of early Neolithic activity and, second, because the Bronze Age field walls remain one of the most significant places in Scotland to understand the complexity of later prehistoric agriculture
8. The exploration of novel proxy indicators of storminess should be encouraged
9. Clarification at a number of localities of the behaviour of the sea surface after the highest Holocene shoreline at *c*. 4500 cal BC in later prehistory and early history is needed because some models imply high relative sea level into the early historic period
10. Greater visualisation through Geographic Information Systems (GIS) of changing coastlines through time would greatly aid the archaeologist in understanding the immediate significance of relative sea level fall
11. A programme of $^{14}C$ and optically stimulated luminescence (OSL) dating is needed to define even a rudimentary chronology of sand dune formation and episodicity, to understand long-term changes in Atlantic Ocean storminess
12. The peat of the Moine Mhor needs to yield a proxy record of later prehistoric and historic hydrological change (cf. Charman *et al* 2006) to link the existing records between Ireland and Scotland (Swindles *et al* 2013)
13. There is a need simply for more pollen data for later prehistory and the historic period in addressing testing specific hypotheses generated by the archaeologist and historian
14. The promising work on providing from pollen data local landscape settings for particular rock-art panels should be developed
15. Macklin et al (2000) attempted to relate phases of later prehistoric and historic agricultural activities to periods of climatic amelioration and *vice versa*. Whilst this study was unconvincing, exploring resilience in sustainable farming practices is increasingly a major concern for archaeologists

16. Pollen analyses to test the archaeological assumption of intervisibility between monuments and from monument to skyline should be welcomed
17. Work on the timing and extent of gleying in soils across the region would lead to a new understanding of agricultural productivity and success
18. New work on understanding the chronology and scale in the region of colluvial and alluvial change is necessary because almost nothing is known of these. They are of direct significance to the archaeologist in that human causation in some events is very likely. The consequence of change has impacts on human communities
19. Careful reconstruction of later Holocene relative sea level fall is needed at Dunadd if we are to fully understand the significance of the coastal setting of this fort. The potential for this is enormous but untapped
20. It would be very good if the pollen analyses of Miller & Ramsay (2001) in the early historic period near Dunadd could be tested at a network of sites
21. We might concede that an environmental history of Iona in the early historic period, though desirable, is unlikely to emerge, and turn to monastic settings where work would be more rewarding
22. It is uncomfortable to think that we know so little about so much of the environmental history of the last *c*. 1500 years in the region.

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Map 1. Devensian Lateglacial and earliest Holocene pollen records:


Barachander (Tipping 1989b); Drimnagall (Rymer 1977); Ford (Tipping 1989b); Inverliever (Tipping 1989b); Loch a' Bhogaidh (Edwards & Berridge 2004); Loch an' t-Suidhe (Lowe & Walker 1986); Loch Barnluasgan (Tipping 1989a); Loch Cill an Aonghais (Peglar in Birks 1980); Lon Glas (Tipping 1989); Mishnish (Lowe & Walker 1986); Na Lona Min (Tipping 1986); Pulpit Hill (Tipping 1991).

Map 2. Sediment records of Holocene sea level change:


Arran (Gemmell 1973); Coll (Dawson *et al* 2001); Gruinart, Islay (Dawson *et al* 1998); Knapdale (Shennan *et al* 2006); Moine Mhor (Haggart & Sutherland 1992); Oban (Bonsall & Sutherland 1992); Oronsay (Jardine 1977, 1987).

Map 3. Records of Holocene geomorphological change:

Carradale, Kintyre (Carter & Tipping 1994; Tipping *et al* 1994); Dalness Chasm, Glen Etive (Brasier *et al* 1987); Dunadd (Miller & Ramsay 2001; Housley *et al* 2004; Housley *et al* 2010); Islay (Cressey unpublished); Loch Etive (Howe *et al* 2002); Oban region (Rhodes *et al* 1992; Macklin *et al* 2000); Torbhlaren (Tipping *et al* 2011).

Map 4. Records of Holocene pedological change:


Achnacree (Soulsby 1976; Carter & Dalland 2005); An Sithean (Barber & Brown 1984); Cul a' Bhaile (Stevenson 1984; Whittington 1988); Iona (Barber 1981); Moine Mhor (Housley, Clarke & Campbell 2007); Oronsay (Paul 1987).

Map 5. Mesolithic-age pollen records:


Bealach Froige, Islay (Edwards 2000); Clashgour (Bridge *et al* 1990); Coire Clachach, Mull (Walker & Lowe 1985); Coire Seilich (Bridge *et al* 1990); Corrour (Walker & Lowe 1979); Coulererach, Islay (Bunting *et al* 2000); Cultoon, Islay (Edwards 2000); Dubh Lochan (Stewart *et al* 1984); Fhuaran, Mull (Walker & Lowe 1985); Gribun, Mull (Walker & Lowe 1987); Gruinart, Islay (Edwards 2000); Iona (Scaife & Dimbleby 1990); Loch a' Bhogaidh, Islay (Edwards & Berridge 2004); Loch a' Chrannag, Mull (Sugden 1999); Fyfe *et al* 2013); Loch an-t Sagairt, Coll (Wicks & Mithen 2013); Loch an t' Suidhe, Mull (Lowe & Walker 1986; Edwards & Sugden 2003); Edwards *et al* 2007); Loch Cholla, Colonsay (Andrews *et al* 1987); Loch Cill an Aonghais (Peglar in Birks 1980); Loch Gorm, Islay (Bunting *et al* 2000); Loch Lomond (Dickson *et al* 1976); Lochan Mor, Iona (Bohncke in Barber 1981); Lochan Taynish (Rymer 1974); Mishnish, Mull (Lowe & Walker 1986); Oban (Davies 1997; Macklin *et al* 2000); Rannoch Station (Walker & Lowe 1979); Rhoin Farm, Kintyre (Edwards & Mackintosh 1988); Sorn Valley, Islay (Edwards 2000); Torbhlaren (Tipping *et al* 2011); Torness, Mull (Walker & Lowe 1985).

Map 6. Later prehistoric and historic period pollen records:


Cairnbaan (Long 2002; Winterbottom & Long 2006); Clashgour (Bridge *et al* 1990); Coire Seilich (Bridge *et al* 1990); Corries, Loch Awe (Davies & Watson 2007); Dalness Chasm (Brasier *et al* 1987); Dubh Lochan (Stewart *et al* 1984); Dunadd (Miller & Ramsay 2001; Housley *et al* 2004; Housley *et al* 2010); Fhuaran, Mull (Walker & Lowe 1985); Glasvaar (Long 2002; Winterbottom & Long 2006); Glengorm (Hale in Martlew & Ruggles 1996); Gribun, Mull (Walker & Lowe 1987); Iona (Bohncke in Barber 1981; Balaam in Reece 1981; Scaife & Dimbleby 1990; Tipping in McCormick 1993); Loch a' Bhogaidh, Islay (Edwards & Berridge 1994); Loch a' Chrannag, Mull (Sugden 1999; Fyfe *et al* 2013); Loch Cholla (Andrews *et al* 1987); Loch Cill an Aonghais (Peglar in Birks 1980); Loch Lomond (Dickson *et al* 1976); Lochan Taynish (Rymer 1974); Oban Davies 1997; Macklin *et al* 2000); Sansum (2004): sites along Loch Awe at Cladich, Fernoch and Glen Nant; Torbhlaren (Tipping *et al* 2011); Torness (Walker & Lowe 1985).