Shieling activity in the Norse Eastern Settlement: palaeoenvironment of the 'Mountain Farm', Vatnahverfi, Greenland

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Abstract

Transhumance agriculture formed a key component of subsistence strategies in the Norse economies of the North Atlantic, with evidence of shielings or *sæters* found in Norway, Scotland, the Faroe Islands and Iceland. It is frequently assumed to have played a role in Norse Greenland, yet little enquiry has been made into such activity. This paper seeks to address this deficit, presenting the first palaeoenvironmental study of a suspected Greenlandic shieling site in the uplands of the former Norse Eastern Settlement. Pollen analysis, ^{14}C and associated proxies are used to date and assess the environmental and landscape impact of shieling activity. Evidence for vegetation disturbance associated with Norse settlement is indicated from c. AD 985, but the shieling itself is interpreted as having been established somewhat later (cal. AD 1050-1150). Initially the site appears to have been used exclusively for grazing of livestock and there is tentative evidence for the use of burning to stimulate the spread of pastures. Pollen influx figures suggest the initiation or intensification of hay production cal. AD 1225-1325, reflecting either the spread of settlement from the lowland valleys, or evolution of the site into a full farm in response to population pressure. A reduction of human impact cal. AD 1300-1390 suggests a reversion to shieling activity, indicating similarities to transhumance in northern Iceland. Abandonment of the site dates within the envelope cal. AD 1325-1415 and is in agreement with previous evidence from Norse Greenland.

Introduction

The Norse expansion across the North Atlantic Ocean began in the early 9th century AD with the colonisation of the Northern Isles of Scotland and the Faroe Islands (Jones, 1984). This westwards movement of people and animals continued for a further two centuries, with the colonisation of Iceland c. AD 870, Greenland in the late 10th century and the establishment of the short-lived settlement of L'Anse aux Meadows in Newfoundland in the early 11th century (Fitzhugh, 2000). *Íslendingabók* (The Book of the Icelanders) indicates that *landnám* (colonisation) in Greenland dates to AD 985 (Krogh, 1967), but offers no insight as to the spatial or temporal progression of settlement thereafter. Palaeoecological (cf. Edwards *et al*., 2008; Schofield and Edwards, 2011) and archaeological studies (cf. Nörlund, 1930; Nörlund and Stenberger, 1934) indicate that the *landnám* period was rapid, with farms established within decades. However, these studies tend to be biased towards iconic locations such the area surrounding Erik the Red's posited farm at *Brattahlið* (Fredskild, 1973; 1978; Edwards *et al*. 2010) or accessible fjord-side locations (see Edwards *et al*., 2008, 2011b; Schofield and Edwards, 2011), which would presumably have been settled during the first wave of colonisation.

The Norse established a pastoral agricultural system in what can be considered a 'pristine' landscape (Dugmore *et al*., 2005) with the primary unit of settlement being the farm (Buckland, 2008; Kaland and Martens, 2000). Hay was grown during the summer months for the overwintering of livestock through the severe Greenlandic winters (Berglund, 1986). This was supplemented with the hunting of wild game, seabirds and marine mammals (McGovern, 1985). These aspects of the Norse subsistence system have been discussed and studied extensively (e.g. McGovern, 1985; Edwards *et al*., 2008; Schofield *et al*., 2008), yet there has

been only limited discussion of the more peripheral elements of Norse farming such as transhumance (see Albrethsen and Keller, 1986). Known to have been practiced in the wider North Atlantic and Norway (Reinton, 1969; Magnus, 1986; Skrede, 2005; Mahler, 2007; Lucas, 2008; Sveinbjarnardóttir et al., 2011), transhumance is a system whereby farmers move animals during summer, exploiting more remote pastures while at the same time reducing the pressure on pastures close to the main farm (Albrethsen and Keller, 1986). Such activity is characterized by small isolated buildings (shielings or *sæters*) often at altitude, but relatively near to a main farm (Reinton, 1969; Albrethsen and Keller, 1986). These structures are common throughout southern Greenland (Albrethsen and Keller, 1986; Guldager, 2002), suggesting that transhumance formed an important part of Norse subsistence strategies.

This paper presents palaeoecological data from a presumed shieling – Norse ruin group Ø70 (Bruun, 1986), widely referred to as the 'Mountain Farm' (Vebæk, 1992) – in the uplands of Vatnahverfi ('land of lakes/waters'; Ingstad 1966) in southern Greenland, and aims to address the deficit of knowledge relating to transhumance activity in Norse Greenland. Primarily the paper seeks to establish how land use developed at this site, and from this evidence to establish whether the Mountain Farm was utilised as a shieling. To date, no such site from Greenland has been examined in this manner, whereas in Iceland, the Faroes and Norway, pollen-analytical data have furnished important insights into the practice of transhumance in the Norse cultural sphere (Kvamme, 1988; Borthwick et al., 2006; Sveinbjarnardóttir et al., 2011).

The Study Site

Ruin group Ø70 comprises eight relatively small structures located in the Vatnahverfi region of the Eastern Settlement. Named 'The Mountain Farm' by Christian Vebæk (1992) because of its location at 260 m a.s.l. (Figure 1), the site was first recorded by Daniel Bruun (1896). The nearest modern settlements are the lower-lying sheep farms of Timerliit 1 km to the northwest, and Igaliku Kujalleq 5 km to the north. Nearby Norse structures are ruin groups Ø69 (located at Timerliit) and Ø167, a large farm complex approximately 3 km to the southwest.

The ruins at Ø70 are situated on a low hill overlooking two lakes fringed with *Carex rostrata* reedswamp and surrounded by *Sphagnum*-Cyperaceae mire (plant nomenclature follows Böcher *et al*. 1968). The vegetation in the wider vicinity of the ruins comprises extensive upland grassland with patches of *Salix glauca* scrub.

Limited excavation of the ruin group was undertaken by Vebæk in 1950. This yielded a surprisingly large quantity and variety of finds relative to the site's small size and presumed function as a shieling (Vebæk, 1992). A total of 76 artefacts were recorded, amongst which was a semi-manufactured iron bar and iron slag. This perhaps indicates that iron working was a supplementary activity practised at the site.

Physical geography

The study area is characterized by rounded mountain topography ranging from sea level to 600 m a.s.l. and interspersed with numerous lakes. Local geology is uncomplicated and dominated by a suite of granites (Allaart, 1976). The surficial drift cover comprises glacial and glaciofluvial deposits of Quaternary age (Feilberg, 1984) which are overlain in places by aeolian sediment sourced from the sandur of the Jespersens Dø glacier 15 km to the northeast (Jakobsen, 1991). The dominant soils are podzols. Climatically the site straddles the

boundary of the sub-continental, sub-arctic and sub-oceanic zones of southern Greenland (Feilberg, 1984). The nearest observational climate data comes from Narsarsuaq (35 km to the north) which experiences mean summer (July) temperatures and annual precipitation of 9.8°C and 696 mm respectively (*ibid*.).

Methodology

Fieldwork and sediment sampling

Fieldwork was undertaken in July 2010. Shallow peat deposits were identified at a small (110 x 46 m) *Sphagnum*-Cyperaceae mire approximately 50 m south of ruin group Ø70 (N 60° 50.762', W 45° 17.478'; Figure 1). The total depth of organic deposits was 155 cm. This was sampled and analysed between 60 and 110 cm using an 8 cm diameter Russian corer (Jowsey, 1966) and the location was recorded using a portable Garmin GPS handset. The core section was protected in plastic guttering and wrapped in polythene before being returned to the University of Aberdeen where it was placed in cold storage (4°C). Sub-sampling and Troels-Smith (1955) recording of the lithostratigraphy were undertaken in the laboratory. Loss-on-ignition (LOI) was measured following 3 h combustion at 550°C (Bengtsson and Enell, 1986).

Pollen analysis

Samples for pollen analysis were prepared using standard NaOH, sieving, acetolysis and flotation (solution density 1.88 g ml^{-1}) procedures (Moore *et al*., 1991; Nakagawa *et al*., 1998). *Lycopodium* tablets were added to each sample to allow the calculation of concentration and influx data (Stockmarr, 1971). Samples were suspended in silicone oil,

mounted on slides and examined using a Nikon E400 light microscope at x400 magnification and counted until a sum of 500 total land pollen (TLP) had been achieved.

Pollen and spores were identified with the aid of Moore *et al.* (1991) and reference material held at the University of Aberdeen. Nomenclature follows Bennett *et al.* (1994) and Bennett (2012a). Taxa absent from these lists follow the nomenclature in Moore *et al.* (1991). The separation of *Betula* pollen into tree (*Betula pubescens*) and shrub (*Betula glandulosa*) varieties was undertaken using grain size diameter measurements (cf. Fredskild, 1973; Mäkelä and Hyvärinen, 1998; Schofield and Edwards, 2011). Where diameter was <20 µm, *Betula* was classified as *B. glandulosa*. Cereal-type pollen grains were identified and categorised following Andersen (1978). Coprophilous fungal spores were identified using van Geel *et al.* (2003). These spores are derived from fungi that grow on animal dung and have been demonstrated to increase at *landnám* following the introduction of grazing herbivores (Schofield and Edwards, 2011). Care must be taken in the interpretation of this proxy as small numbers have also been shown to be present both before and after Norse occupation (Gauthier *et al.*, 2010; Schofield and Edwards, 2011). Pollen diagrams were constructed using TILIA and TGView software (Grimm, 1993; 2012) with percentages based upon the TLP sum.

Charcoal analysis

The area covered by microscopic charcoal in pollen residues was measured using a microscope eyepiece graticule at a magnification of x400. Due to the frequently high concentrations of charcoal, only the first 50 fragments larger than 50 μm^2 were included in the analysis (cf. Edwards *et al.*, 2008; Schofield *et al.*, 2008). Between 93 and 83 cm where charcoal was particularly abundant, the point count method was employed (Clark, 1982). A total of 8800 points were applied to achieve a <5% error in charcoal estimates. Techniques

employed for determining pollen concentrations were used to calculate charcoal influx (cf. Swain, 1978). Additionally, charcoal to pollen (C:P) ratios were calculated to check whether charcoal abundances were changing as a consequence of sedimentation effects (Patterson *et al.*, 1987).

Numerical analysis

CONISS (Grimm, 1987) was used to assist with the biostratigraphic zonation of the pollen diagram following square root transformation of percentage data. Rarefaction analysis (Birks and Line, 1992) was performed in *psimpoll* (Bennett, 2012b). Principal components analysis (PCA [Figure 2]) was undertaken using CANOCO 4.5 (ter Braak and Šmilauer, 2002) after detrended correspondence analysis (DCA) indicated a linear rather than unimodal pattern to the dataset (Lepš and Šmilauer, 2003).

Radiocarbon dating

Seven plant macrofossil samples (Table 1) were submitted for AMS ^{14}C dating. Sediment samples were gently disaggregated in weak NaOH and washed through a 125 µm sieve using distilled water. Residues were examined under a low power binocular microscope and plant macrofossils picked for dating. Seeds were identified using Cappers *et al.* (2006) and modern reference material held at the University of Aberdeen. Measurements were undertaken on terrestrial plant macrofossils where possible, with the humic acid fraction of small (1cm^3) peat samples used only where suitable macrofossils for dating were absent. AMS samples were processed and measured at SUERC, East Kilbride, and calibration was undertaken using the IntCal09 calibration curve (Reimer *et al.*, 2009) and CALIB v6.0. Two approaches were explored to generate a chronology: *Bacon,* which employs a Bayesian methodology (Blaauw and Christen, 2011) and *Clam*, which offers a 'classical' approach (Blaauw, 2010).

Results

Chronology

The results of ^{14}C dating are presented in Table 1. All the dates, excepting the uppermost, form a clear stratigraphic sequence with no age inversions. The date at 64-61 cm (SUERC-33441) on a *Betula* twig provided a modern radiocarbon age and is unquestionably not *in situ*. The most likely explanation is that this fossil was moved down the profile during sampling and it has therefore been omitted from model runs. The two age-depth models are presented in Figure 3 and the 2σ age ranges for zone boundaries and base and top of the analysed sequence are compared in Table 2. The two models compare favourably and there is much overlap in the 2σ age envelopes from each (Table 2). The main differences are that Bacon provides: (i) a model with more conservative confidence intervals; (ii) marginally older dates for events post-dating the 12th century AD, and slightly younger dates than Clam for events pre-dating that period; and (iii) Bacon suggests less extreme changes in the accumulation rate than does Clam. The latter produces a curve which intercepts the basal date (SUERC-33450). The possibility of this date being affected by 'old' carbon error cannot be discounted as it was undertaken on humic acid (cf. Edwards *et al*., 2008; Schofield *et al*., 2008). Without further chronological control below the basal date, it is impossible to ascertain which age-depth relationship is the more likely (Telford *et al.,* 2004). In the absence of convincing evidence that the basal age determination is incorrect, the 'classical' approach (*sensu* Blaauw, 2010) offered by Clam has been adopted. The choice of model has no significant bearing on the period of inferred human occupation at the site.

Lithostratigraphy

The mire stratigraphy is broadly homogeneous through the analysed sequence and comprised a brown to dark brown sandy and humified peat. Humified *Sphagnum* remains were abundant between 96 and 93 cm. Sandy peat continued below the analysed sequence, grading into sand at 155 cm. Above the analysed sequence the sandy peat continued up to 34 cm where there was a sharp contact onto poorly-humified *Sphagnum* peat. LOI is low throughout at ≤ 40%. The core stratigraphy is presented alongside the pollen-analytical data in Figure 4.

Palynology

The environmental baseline (LPAZ MF-1)

Local pollen assemblage zone (LPAZ) MF-1 opens cal. 315 BC - 40 BC and is dominated by Cyperaceae (c. 40-50%) indicating a local sedge-dominated mire community. Combined *Salix* (willow) and *Betula glandulosa* (dwarf birch) pollen frequencies of c. 20-30% suggest that hill slopes supported reasonably dense scrub. Poaceae (grasses) representation of c. 10-15% point to the presence of limited grassland and herbslope communities (*sensu* Böcher *et al*., 1968; Feilberg, 1984).

The pre-landnám environment (LPAZ MF-2a) and regional landnám (LPAZ MF-2b)

The MF-1/2a zone boundary dates to cal. AD 500-625. Subtle changes are evident within the pollen assemblages, such as an increase in Poaceae, and more frequent occurrences for several minor herbaceous pollen types (e.g. *Potentilla*-type [cinquefoils]), whilst *Betula* pollen decreases. This perhaps reflects the expansion of grassland and herbslope communities (*sensu* Böcher *et al.*, 1968) at the expense of dwarf-shrub heath and scrub. The intermittent appearance of *Rumex acetosa* (common sorrel) pollen in samples in this zone is notable given that this taxon is widely regarded as having been introduced to south Greenland by the Norse

settlers (e.g. Fredskild, 1988). The values recorded here (<1%) could conceivably indicate a pre-settlement local presence for the plant, although at such low frequencies the possibility of long-distance transport from distant sources should not be discounted (cf. Fredskild, 1973).

Similar palynological changes to those witnessed in MF-2a have been noted before *landnám* in the Faroe Islands where an expansion of herbaceous types was interpreted as potentially representative of an early farm (Hannon and Bradshaw, 2000). Such an explanation seems unlikely at the Mountain Farm given the lack of a full suite of Norse palynological indicators (Edwards *et al*., 2011a) and an absence of microscopic charcoal. It seems more plausible that developments in LPAZ MF-2a relate to grazing by wild herbivores such as caribou (reindeer; *Rangifer tarandus*), which were previously common across the region (Ingstad, 1966). The appearance and steady increase of spores from coprophilous fungi (*Sporormiella*-type and *Sordaria*-type) support this view. The situation may have been similar to that around Kangerlussuaq, western Greenland (67° 0' N, 50° 41' W). Here sustained grazing by caribou has led to the creation of patches of grassland (or 'greens') with a near-uniform cover of non-flowering *Poa pratensis* (smooth meadow-grass) (Fredskild and Holt 1993).

Subtle changes separate LPAZ MF-2a from MF-2b, the onset of which dates to cal. AD 945-1055 and encompasses the early *landnám* period (dated from historical sources to AD 985; Seaver, 2010). Poaceae pollen rises sharply to c. 30%, *Salix* falls from c. 22% to 15%, *Betula* continues to decline and there are traces of *Cerastium*-type (mouse-ears), Lactuceae (dandelions) and Caryophyllaceae (pinks) (see Figure 4). This suggests further expansion of grassland and herbslope communities at the expense of dwarf-shrub heath. The mire surface appears wetter during this period as there is an increase in visible *Sphagnum* remains within the sediment column (96-93 cm). Rather than representative of a climatic

change, this could be a consequence of reduced evapotranspiration rates following the reduction in the area covered by *Salix* and *Betula*.

Sporormiella-type (c. 5%) signals the continued presence of grazing herbivores and a sustained decline in LOI (41% to 35%) may indicate an intensification of grazing-related erosion. *Rumex acetosella* (sheep's sorrel), a Norse introduction (Fredskild, 1973; Edwards *et al*., 2011a; Schofield *et al*., in press), is recorded at the base of the zone as is a slight increase in microscopic charcoal, both of which are consistent with *landnám* elsewhere in Greenland (Edwards *et al*., 2008; Edwards *et al*., 2011a). Yet, the intensity of these changes is somewhat muted, a pattern similar to that observed by Schofield and Edwards (2011) at Qinngua. There, traces of pollen types considered indicative of a Norse 'footprint' (Edwards *et al*., 2011a) were interpreted as representative of regional *landnám* before the establishment of local settlement. Adopting a similar interpretation, the single grain of *Rumex acetosella* and a minor increase in microscopic charcoal could be the result of long distance transport from elsewhere in Vatnahverfi, or the Eastern Settlement. The apparent Norse signal could thus represent regional activity and the arrival of the earliest settlers.

Local landnám (LPAZ MF-3)

If LPAZ MF-2b represents a 'regional' *landnám*, then the opening of MF-3 (dating to cal. AD 1050-1150) undoubtedly marks localised *landnám*. The C:P ratio, which peaks at the opening of the zone (Figure 4), clearly reflects burning at the site, while the charcoal influx value (Figure 5) is four times greater than the highest influx values recorded elsewhere in the Eastern Settlement (cf. Edwards *et al*., 2008, Schofield and Edwards, 2011) where microscopic charcoal has been interpreted as predominantly reflecting domestic activities such as cooking and heating. At the Mountain Farm the unusually high charcoal values at the opening of MF-3 may point to managed burning of the dwarf-shrub heath to encourage the

spread of grassland (cf. Dugmore *et al.,* 2005). There is supposed evidence for this practice in the Western Settlement (Iversen, 1934; Fredskild and Humle, 1991), but high resolution data from Iversen's key site indicates a temporal disconnect between *landnám* and the use of fire for inferred landscape modification (KJE and JES unpublished).

The continued rise in Poaceae to c. 40-45%, alongside a general decline in Cyperaceae from c. 35% to 20% and fluctuations in *Salix* and *Betula*, suggest the expansion of grassland pasture and perhaps hayfields at the expense of mire and dwarf-shrub heath. Aside from these broader-scale changes in the pollen assemblage, an increasing rarefaction index, rising to a maximum value of 26, apparently confirms a diversification in the habitats within the pollen catchment area. The expansion of pollen from ruderal plants such as Brassicaceae (cabbage family; c. 1-4%), possibly representing *Capsella bursa-pastoris* (shepherd's purse) (cf. Fredskild, 1978), *Polygonum aviculare* (knotgrass; trace) and Lactuceae (up to 1%) probably indicates disturbed ground around buildings and areas of habitation (Schofield *et al.*, 2007). *Cerastium*-type pollen (c. 1%) conceivably reflects *Stellaria media* (common chickweed) (Fredskild, 1978) growing in a similar habitat, or one of a number of herbs from the same genus growing in pasture with *Ranunculus acris*-type (meadow buttercup; c. 2-8%). *Rumex acetosella* (c. 1-3%) points to an expansion of grazed heaths, and an abundance of coprophilous spores (*Sporormiella*-type, rising to c. 30-40%), may imply high stocking densities and heavy grazing (cf. Graf and Chmura, 2006).

A major decline in LOI from c. 35% to 20% and a sharp peak in undifferentiated fern spores (c. 4%) in the middle of the zone may suggest widespread landscape disturbance linked to grazing. Erosion of catchment soils and a consequent inwash of secondary pollen could account for the anomalously high *Betula* pollen counts (c. 45%) near the opening of the zone (cf. Gathorne-Hardy *et al.*, 2009). Over 75% of the *Betula* grains in this sample are damaged compared to c. 20-35% of the grains in the samples immediately above and below,

suggesting some bias within the assemblage. MF-3 seems to reflect a mosaic of heavily grazed natural vegetation communities including mire, dwarf-shrub heath and grassland, along with the emergence of culturally-related pasture and ruderal communities.

Intensification (LPAZ MF-4)

The opening of LPAZ MF-4 (cal. AD 1225-1325) marks a sharp change in pollen assemblages. Poaceae peaks at c. 50-55%, while *Salix* (c. trace to 1%), tree and shrub *Betula* (c. 2-3%) and Cyperaceae (c. 7-10%) continue to decline. Rarefaction values fall to c. 20-21 mid-zone, suggesting decreased diversity, while the representation of inferred Norse apophytes (e.g. *Cerastium*-type) increases. The most dramatic change is in *Ranunculus acris*-type which reaches 30%. There are also indications of declining grazing intensity with *Sporormiella*-type falling to c. 10-12% whilst rising LOI values may indicate a reduction in soil erosion (see Figure 4).

A further development is the appearance of Poaceae in the *Hordeum*-type size range (Andersen, 1978). Whether these large pollen grains (Table 3) reflect actual attempts to grow barley is uncertain. On the basis of annuli and pore measurements recommended by Tweddle *et al.* (2005), it seems more likely that they represent *Elymus arenarius* (lyme grass), which generally grows on sandy or stony ground close to the coast and in river valleys (Böcher *et al.*, 1968). Although neither of these environments is widely represented in the pollen catchment of the Mountain Farm today, it is possible that disturbance from grazing created patches of sandy ground suitable for the plant to invade. Alternatively, *Elymus* pollen may have blown into the deposit from elsewhere in Vatnahverfi, such as from the sandur area to the north.

There are clear indications that the pollen assemblage from LPAZ MF-4 records a significant shift in land use. PCA (Figure 2) shows samples from MF-4 plotting in a different

ordination space to those from MF-3. Given the consistently high Poaceae pollen percentages (c. 50-55%) in MF-4, it is possible that this shift reflects the initiation, or a significant expansion, of seasonal hay growing at the site. In a modern study of pollen vegetation relationships in southern Greenland, Schofield *et al.* (2007) recorded Poaceae values in the range 37% to 96% in the margins of hayfields. Considering that modern farms benefit from the use of pesticides and industrial fertilizers, the values of 50-55% in MF-4 could be viewed as abundant. Influx data (Figure 5) also points towards a significant increase in the productivity of vegetation communities with both Poaceae and *Ranunculus acris*-type rising sharply. Although improved temperatures can be responsible for increased pollen influx, such an explanation seems unlikely in this case. Influx values change little amongst the other taxa, implicating the influence of a factor other than climate.

Abandonment (LPAZs MF-5a and b)

A reduction of human activity is recorded in MF-5a (beginning cal. AD 1300-1390). Poaceae falls to 30%, *Ranunculus acris*-type declines to 10%, and other 'weeds' such as *Cerastium*-type, Brassicaceae and Lactuceae become rare or absent; these patterns are mirrored in the pollen influx figures (Figure 5). Sub-arctic steppe (*sensu* Böcher *et al.*, 1968) appears to invade these managed communities as denoted by the rapid expansion of Cyperaceae from c. 7% to c. 50%. There is a minor expansion in *Salix* from c. 3% to 8%, but no response in *Betula glandulosa* or *B. pubescens*, suggesting that there was not a major recovery in the shrub cover. Set beside these broad vegetational changes, there appears to be a continuity of grazing, with *Sporormiella*-type relatively constant until the MF-5a/b boundary (cal. AD 1325-1415) where it declines sharply to trace values. Microscopic charcoal follows a slightly different pattern, with a marked increase in C:P and influx noted at the start of MF-5a before charcoal becomes absent above the MF-5a/b boundary.

The opening of LPAZ subzone MF-5a appears to reflect the abandonment of hayfields, although use of the site continued, perhaps on a seasonal basis only, as microfossil signatures for grazing and burning are still evident. The opening of sub-zone MF-5a (cal. AD 1300-1390) is broadly contemporaneous with the posited decline into the 'Little Ice Age' (LIA) (Miller *et al*., 2012) suggesting that a possible climatic downturn was felt relatively early at the Mountain Farm. The abrupt termination of charcoal influx at the MF-5a/b boundary suggests the abandonment of even seasonal usage of Ø70, or the wider Vatnahverfi area, sometime within the period cal. AD 1325-1415. Subzone MF-5b therefore seems to reflect the re-establishment of natural vegetation following the removal of Norse influence. The continued presence of some Norse apophytes (e.g. *Rumex acetosella*) along with *Sporormiella*-type in post-abandonment landscapes is not uncommon (e.g. Edwards *et al*., 2011b) and the latter may reflect the return of caribou or other small mammals (Raper & Bush, 2009).

The post-Norse landscape (LPAZ MF-6)

A large increase in *Salix* pollen (c. 20-25%) reflects the re-emergence of substantial areas of dwarf-shrub heath at the opening of LPAZ MF-6 (cal. AD 1335-1455). *Betula* pollen remains rare (c. 1-2%), indicating little to no regeneration of dwarf or tree birch. This is unsurprising given that *Betula* is less cold tolerant than *Salix* (Kuivinen and Lawson, 1982). These changes along with the continued absence of microscopic charcoal and the intermittent presence of *Sporormiella*-type would seem to confirm that the site was abandoned.

Discussion

Was the Mountain Farm a shieling?

Previous authors are of the opinion that the Mountain Farm was occupied temporarily as a summer shieling (Bruun, 1896; Vebæk, 1992), but does the palaeoenvironmental evidence support this claim? Traditionally, *sæters* in the Norse tradition have been divided into full, haymaking and dairy shielings (Reinton, 1969), an idea developed further by Albrethsen and Keller (1986) who suggested a model that may have worked in a Greenlandic context. This is summarised in Table 4 along with our hypothesized palynological signatures for each of the three stages associated with such activity.

Assuming that LPAZ MF-3 reflects local *landnám*, this can be used as a point of departure for examining whether palaeoenvironmental evidence can classify the shieling at Ø70. Evidence for the grazing of animals is present in the form of high numbers of spores from the coprophilous *Sporormiella*-type (HdV-113) and perhaps also in the declining LOI values (see Figure 4) which may indicate soil erosion initiated by grazing and trampling. A diverse pollen assemblage including the Norse apophyte *Rumex acetosella*, suspected to respond to grazing, provides further evidence for grazed areas (Schofield and Edwards, 2011). This discounts the possibility of the site having been a simple haymaking shieling. In this context a general decline in pollen influx may be an indication of grazing-suppressed pollen production (cf Waateringe, 1993).

Palaeoenvironmental evidence can therefore eliminate one of the possible models, but determining whether the Mountain Farm operated as a dairy or full shieling on the basis of such evidence is more difficult. Dairy shielings might be expected to have similar impacts to a full shieling, with grazing occurring for both categories alongside increased burning associated with milk sterilization (Albrethsen and Keller, 1986). There is evidence for both activities in MF-3, yet the strength of the pollen, charcoal and coprophilous fungal spore evidence seems to point towards the site having been occupied for extended periods. Dairy shielings would have been occupied for only short periods of perhaps up to one month (*ibid.*),

which would be unlikely to produce the strong grazing and burning signals seen in the palynological record for Ø70. It therefore seems improbable that the site was being used as a dairy shieling.

Archaeological evidence would also support this conclusion. A total of 8 ruins are present, amongst which is a large dwelling (29 x 12 m) containing 5 rooms and a large (21 x 9 m) structure of uncertain use which was probably a byre (Vebæk, 1992). This number of structures would almost certainly not have been present at a dairy shieling (Albrethsen and Keller, 1986). A note of caution is necessary as the chronology of the ruins is highly uncertain (Roussell, 1941; Vebaek, 1992) and they may relate to a later period than that represented in MF-3.

On the basis of the palaeoenvironmental evidence alone, it would seem reasonable to assume that the Mountain Farm operated as a full shieling during the period represented by MF-3, with the grazing of livestock perhaps just one of a wider range of activities (cf. Reinton, 1969; Lucas, 2008). Palynology can offer little insight into the nature of supplementary activities except to suggest whether haymaking may have been one of them. High Poaceae frequencies of c. 40-45% during MF-3 imply hay production, but declining influx of Poaceae pollen suggests otherwise. When the associated taxa are examined there are no real indications of hayfields. The contribution from *Ranunculus acris*-type is low (in this LPAZ, at least) as are other representatives of modern pollen assemblages from hayfields in southern Greenland (Schofield *et al*., 2007).

The beginning of LPAZ MF-3 and the inferred commencement of shieling activity dates within the interval cal. AD 1050-1150. This apparent delay in shieling establishment could be considered unusual, but given an initially small settler population and the time required to colonise a new landscape (Anthony, 1990), such a finding may actually be expected. Early settlement would almost certainly have been low density (Lynnerup, 1998)

and lowland pastures available for grazing would have been plentiful. Notwithstanding such considerations, the first settlers would also have had to focus on constructing homes, clearing land for pasture and building up stock numbers whilst surviving in a new landscape (Rousell, 1941; Vebaek, 1943). In this context, exploration and the establishment of outposts in the hinterland of Vatnahverfi was unlikely to have been an immediate priority (cf. Wallace, 2009). Accepting such a scenario, the slightly delayed appearance of shielings would reflect a natural progression in response to population pressure.

A change in site use appears to be indicated from the opening of MF-4 (cal. AD 1225-1325). Rising LOI and lower frequencies of *Sporormiella*-type spores suggest a decline in grazing or a shift of grazing activity away from the sampling site (Figure 4), while a large increase in Poaceae influx (Figure 5) points to the establishment of hayfields. Both developments could reflect continuity of the site as a shieling but with the range of activities expanded to incorporate haymaking. The addition of hayfields at the Mountain Farm could reflect an attempt to bring more marginal land into production to support larger stock numbers around two to three centuries after *landnám*, when the Norse population was probably at its peak (Keller, 1989; Lynnerup, 1998). Vegetational changes such as an increased presence of apophytes and further declines in dwarf-shrub heath also compare favourably to patterns seen upon farm establishment elsewhere in Greenland (Edwards *et al*., 2011a) and Iceland. In this context an alternative scenario is that the shieling evolved into a permanently occupied farm in response to increasing population pressure (a common occurrence in Iceland [Sveinbjarndóttir, 1991; Lucas, 2008]). A broad domestic assemblage of artefacts and the large number of structures, including a multi-roomed house and probable byre (Vebaek, 1992) may then be evidence of this development.

The Mountain Farm and shielings in the Norse cultural sphere

Shielings can arguably be traced back to at least the 1st millennium BC and have a long tradition in the mountains of Western Norway (Magnus, 1986; Kvamme, 1988). Their appearance at *landnám* in Iceland and in the Faroe Islands is therefore unsurprising. Across the region their primary function was the same – to exploit higher mountain pastures while simultaneously reducing pressure on grazing areas close to the main farm (Lucas, 2008). Archaeological investigation into the history of the shieling tradition across the North Atlantic is patchy, and Reinton's (1969) study, which proposed three main shieling types, has often formed the starting point for historical enquiry. The wider applicability of this Norwegian model, which formed the basis of Albrethsen and Keller's (1986) interpretation of Greenlandic shielings, is debatable.

In Iceland the model has been found to be of limited utility (Sveinbjarndottir, 1991). Some shielings were abandoned as early as the 11th century (Lucas, 2008) whilst others in northern Iceland developed into tenanted farms (Sveinbjarndóttir, 1991) and some perhaps alternated between the two (Sveinbjarndóttir, 1991; Sveinbjarndóttir *et al*., 2011). Indeed, Lucas (2008) proposes that some Icelandic 'shielings' may never have been intended for such use, and rather were markers of land claims in an evolving cultural landscape. Conversely, and unlike those in Iceland and Norway, Faroese shielings gradually disappear following changing land management practices from the 12th century onwards (Mahler, 1990; Borthwick *et al*., 2006).

Despite the varying trajectories of the system in each area, archaeological excavations do suggest similarities between each region. For instance Norðungusel in Kjarardalur, Iceland (Sveinbjarnardóttir *et al*., 2011) is comparable to Argisbrekka in the Faroes (Mahler, 1991, 2007). Both sites show strong similarities to those in Norway (cf. Magnus, 1986), being located within 3 km of core settlement areas or neighbouring farms and comprising around 6-10 structures, some of which contained internal divisions (Magnus, 1986; Mahler, 1991;

Skrede, 2005). The material culture is also similar, pointing to the production of textiles and iron working being subsidiary activities. However, there is again much variety in the Icelandic types. For instance, at Pálstóftir in eastern Iceland there are only four structures located over 3 km from the nearest farm and hunting appears to have been the primary activity (Lucas, 2008).

The Mountain Farm is therefore unremarkable, on the basis of geography and material culture, from the majority of shielings in the Norse-settled North Atlantic, suggesting that Albrethsen and Keller's (1986) assumptions are sound. The site is c. 1 km from the nearest farm, it had a similar material culture, and it comprised 8 ruins with internal divisions (Vebæk, 1992). Pollen analyses in Norway and parts of Iceland, where there is strong evidence for grazing-induced erosion and the clearance of scrub/woodland to allow hay production, also point to a similar conclusion (Kvamme, 1988; Moe *et al*., 1988; Sveinbjarnardóttir *et al*., 2011). Yet the pollen data from the Mountain Farm also imply a phased development to the site, with a full shieling initially, followed by a small (full) farm c. cal. AD 1225-1325 and then perhaps a return to shieling status c. cal. AD 1300-1390. Current evidence indicates that the evolution of shielings into farms, and vice versa, probably did not occur in Norway and certainly did not in the Faroes where the shieling system was abandoned in the 12th century. The Mountain Farm, at least initially, may have been similarly structured to those in Norway, before evolving in a manner comparable to shielings known from northern Iceland (Sveinbjarnardóttir, 1991). This may be unsurprising considering that most of the Norse Greenlanders were probably Icelanders and/or their descendants.

Conclusions

Shielings and transhumance agriculture have long been suspected in Greenland on the basis of their appearance at other North Atlantic islands colonized by Norse settlers. Albrethsen and Keller (1986) were the first to provide a framework for understanding how they might relate to this wider evidence. Prior to the current paper, no attempt has been made to test the assumptions of their model. The high resolution pollen-analytical approach adopted here has allowed for a greater understanding of these sites. Primarily the data show a palynological signature comparable with other farm sites in the Norse Eastern Settlement, but with tentative indications of fire having been used for landscape management and evidence for extensive herbivore grazing. A shieling system is indicated in which a full shieling was established cal. AD 1050-1150, which may have evolved into a farm in its own right cal. AD 1225-1325, and perhaps returned to shieling status cal. AD 1300-1390. This phased development is comparable to some shielings in northern Iceland, but differs from the Faroes and Norway, where there are no indications of shielings evolving into farms. Data from Ø70 suggests that although largely unremarkable in the context of the wider Norse world, transhumance agriculture at the Mountain Farm may have evolved in a manner comparable to parts of northern Iceland. The possibility of such developments are not noted by Albrethsen and Keller (1986), suggesting that a more nuanced use of their model may be required for an understanding of transhumance in Greenland.

Acknowledgements

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Figure 1. Location maps: (A) the Norse Eastern Settlement in Greenland; (B) Vatnahverfi within the Eastern Settlement; (C) the Mountain Farm and other sites mentioned in the text (D) Photograph looking southwest across the site. The ruin group can be seen in the foreground and the white cross denotes the sampling location (Photograph K.J. Edwards, July 2010).
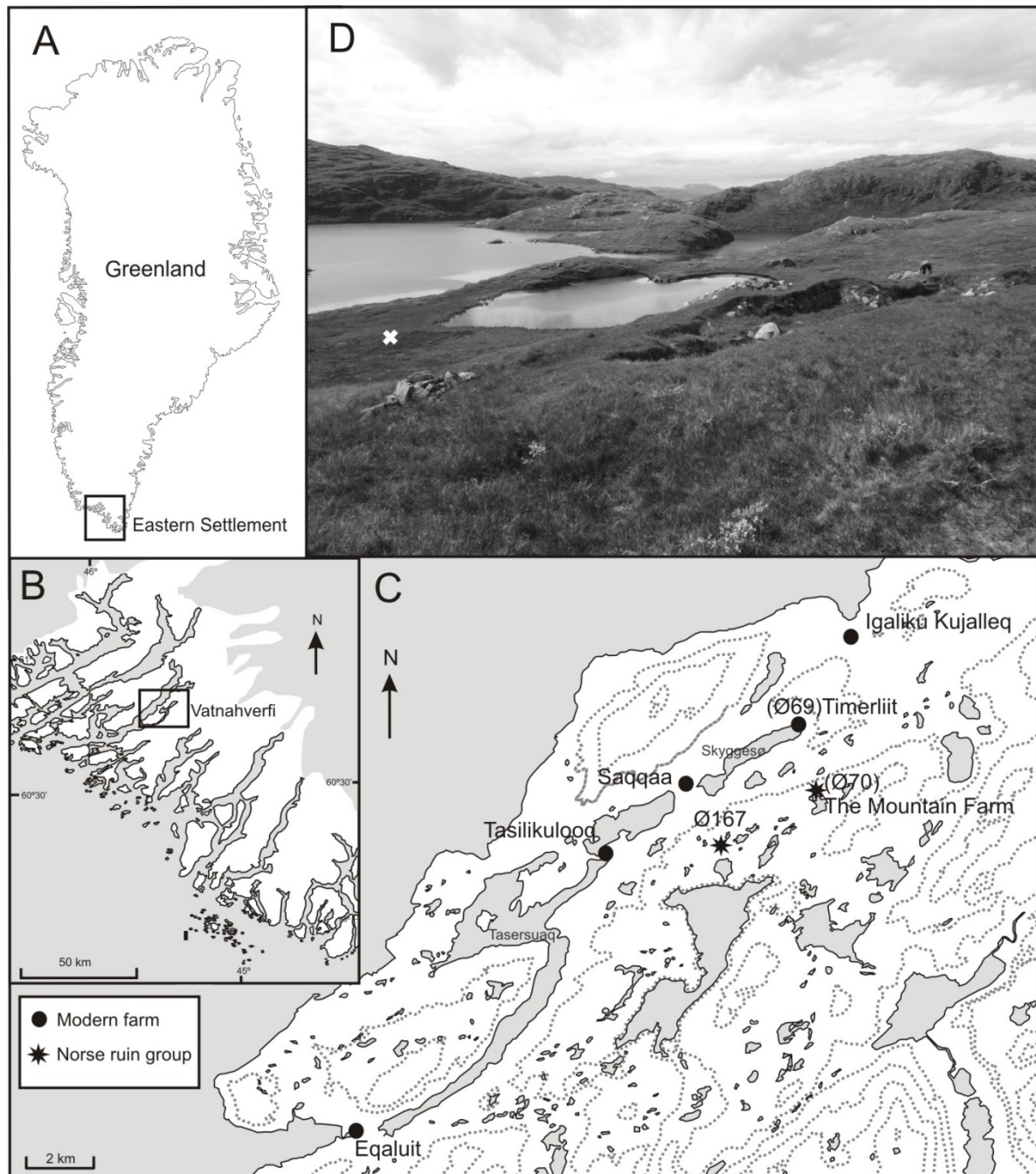
Figure 2. (A) PCA of pollen types and associated proxies from the Mountain Farm (selected taxa only). Key to taxon labels: Api, Apiaceae; BetG, *Betula glandulosa*; BetP, *Betula pubescens;* Brass, Brassicaceae; Cary, Caryophyllaceae; Cer, *Cerastium*-type; C:P, Charcoal to pollen ratio; Cyp, Cyperaceae; Emp, *Empetrum nigrum*; Eq, *Equisetum*; Gal, *Galium*-type; Gent, Gentianaceae; Hor, *Hordeum*-type; Lac, Lactuceae; Lyco, *Lycopodium annotinum*; Poa, Poaceae; Pot, *Potentilla*-type; Ptero, Pteropsida monolete indet.; Ranu, *Ranunculus acris*-type; Rose, Roseaceae; Rsella, *Rumex acetosella*; Rtosa, *Rumex acetosa*; Sal, Salix; SaxO, *Saxifraga oppositifolia*-type; Spha, *Sphagnum*; T55a, *Sordaria*-type; T113, *Sporormiella*-type; Unk, Unknown and indeterminable; Vacc,*Vaccinium*-type. (B) PCA plot of sample scores for the Mountain Farm pollen and spore dataset
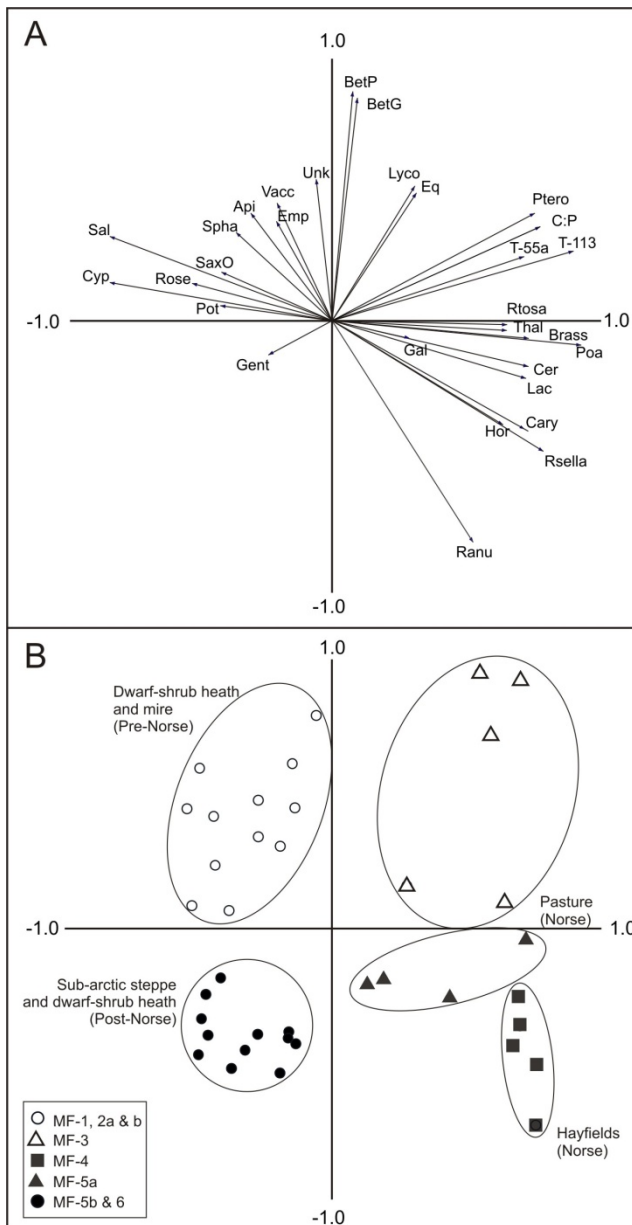
Figure 3. Age-depth models for the Mountain Farm profile generated using Bacon (Blaauw and Christen, 2011) and Clam (Blaauw, 2010) software. For Bacon, the mean deposition time was set at 30 yr cm^{-1} and memory strength and mean at 50 and 0.8 respectively to allow a high degree of flexibility in the accumulation curve. The shaded area in the model indicates all possible age-depth models and the dotted line reflects the 2σ age range; darker areas indicate increased certainty. Shapes show calibrated calendar age distributions of individual dates. For Clam, a smoothed spline was fitted through the dates and extrapolated from 73 cm to the top of the pollen analysed sequence at 62 cm. The black line indicates the best-fit model and the grey shaded regions indicate the 2σ age range.
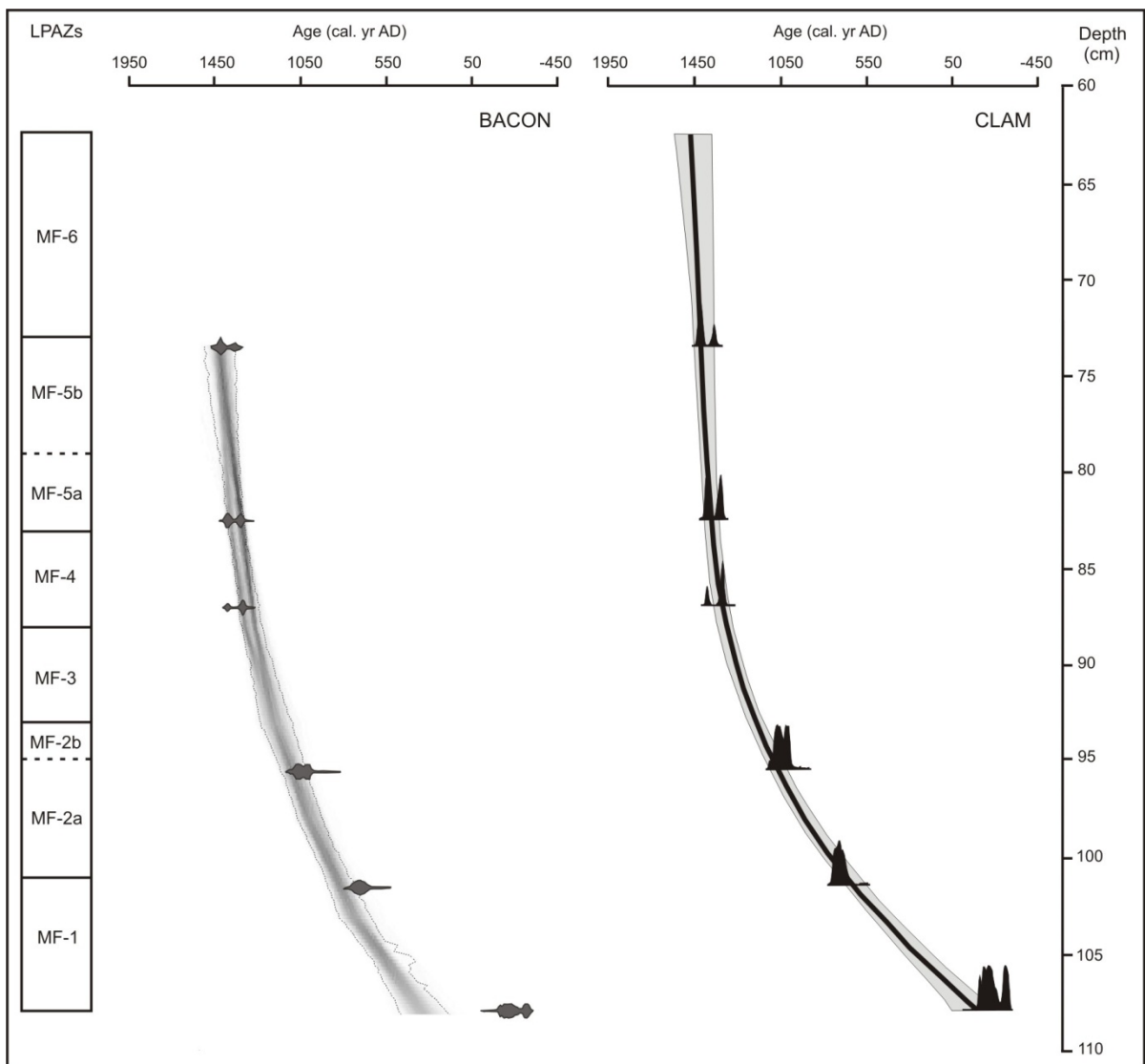
Figure 4. Percentage pollen and spore diagram for the Mountain Farm displaying selected taxa (minimum sum = 500 TLP). Also shown are the modelled calendar ages, modelled 2-sigma calendar range, uncalibrated ^{14}C dates, lithology, loss-on-ignition, microscopic charcoal, pollen concentration and the rarefaction index . + indicates < 1% TLP.
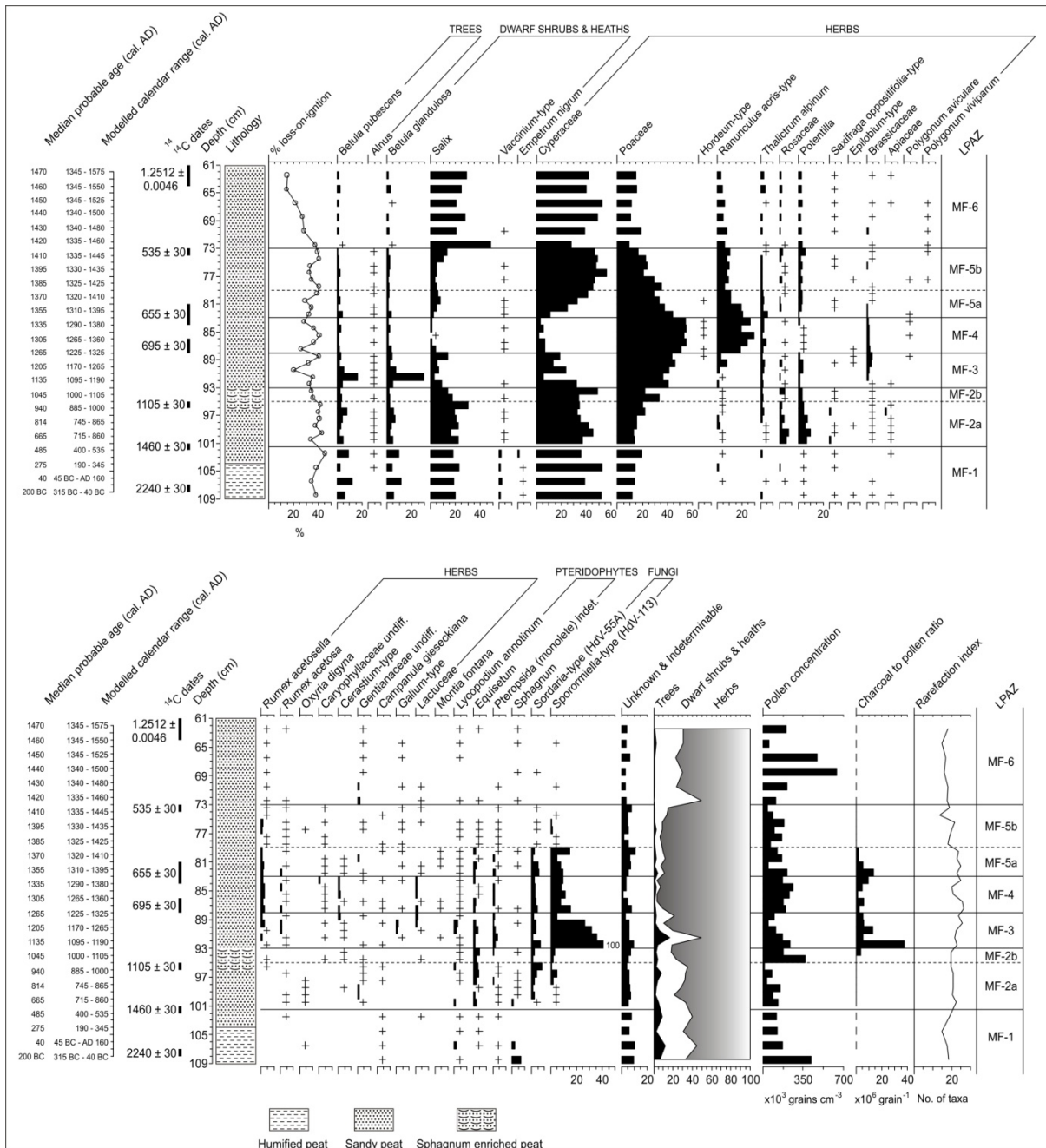
Figure 5. Influx diagram displaying selected pollen types, spores and charcoal (exaggeration curves where present are x5). .

Table 1. Radiocarbon dates for the Mountain Farm profile.

Depth below modern surface (cm)	Lab code	Material	^{14}C yr BP (±1σ)	Cal BC/AD (±2σ)	δ^{13}C (‰)
64-61	SUERC-33441	*Betula* twig	1.2514± 0.0046	Modern	-30.4
74-73	SUERC-33442	Peat (humic acid fraction)	535±30	AD 1320-1440	-29.3
84-81	SUERC-33443	*Salix* twig	655±30	AD 1280-1395	-26.7
88-86	SUERC-33444	*Carex* sp. nutlets, *Ranunculus acris* seeds, *Stellaria media* seeds, and bryophytes	695±30	AD 1265-1390	-29.1
96-95	SUERC-33445	*Sphagnum* sect. Acutifolia leaves and branches	1105±30	AD 885-1015	-23.6
102-101	SUERC-33446	*Betula* twig	1460±30	AD 550-650	-27.8
108-107	SUERC-33450	Peat (humic acid fraction)	2240±30	390-205 BC	-27.5

Table 2. Comparison of the two age-depth models generated in Figure 3. Age ranges in the table are cal. AD unless otherwise stated. Numbers in parentheses are the maximum *a posterior* probability, in the case of Bacon, and the best-fit model for Clam. ND denotes no data.

Horizon	Depth (cm)	Ages (cal. AD)	
		Bacon	Clam
Top	62	ND	1345-1575 [1470]
MF-5b/6	73	ND	1335-1455 [1415]
MF-5a/5b	79	1305-1415 [1330]	1325-1415 [1380]
MF-4/5a	83	1265-1365 [1295]	1300-1390 [1345]
MF-3/4	88	1160-1290 [1220]	1225-1325 [1265]
MF-2b/3	93	990-1175 [1110]	1050-1150 [1090]
MF-2a/2b	95	930-1090 [1045]	945-1055 [995]
MF-1/2a	101	660-810 [775]	500-625 [580]
Base	108	190-420 [375]	315-40 BC [200 BC]

Table 3. Summary of pollen categorised as *Hordeum*-type in LPAZ-MF4 (classifications are solely on the basis of size) with comparative measurements of wild grass and cereal species from modern populations (after Andersen, 1978).

Depth (cm)	Grain dimensions (µm)			Annulus diameter	Pollen index	State of Preservation
	Axis A	Axis B	Mean			
Fossil pollen						
80.5	40.67	34.03	37.35	8.3	1.20	Folded
83.5	43.16	33.2	38.18	9.96	1.30	Folded
	43.16	33.2	38.18	8.715	1.30	Folded
84.5	43.16	34.86	39.01	8.715	1.23	Folded
	44.82	36.52	40.67	9.13	1.22	Folded
85.5	44.82	34.86	39.84	8.715	1.29	Folded
87.5	39.84	34.86	37.35	8.3	1.14	Folded
88.5	44.82	44.00	44.41	8.3	1.01	Excellent
Species	Wild grasses					
Elymus arenarius	-	-	43.86	8.88	1.08	-
Elymus repens	-	-	37.73	8.81	1.11	-
Cereals						
Hordeum vulgare	-	-	37.29	8.23	1.14	-

Table 4. Expected activities and associated structure for different types of shieling (summarised from Albrethsen and Keller [1986]). A 'signature' is proposed for each activity which may be tested against the palynological record.

Shieling type	Activities and associated structure	Hypothesized palynological signature	Palynological visibility
Full	Full time summer occupation with animals grazing associated pastures through the summer months. Possibly dairying and haymaking. Large number of structures including a barn, byre, living quarters and pens.	• High influx of Poaceae pollen associated with haymaking. • Large numbers of coprophilous fungal spores (HdV-113 and HdV55a) associated with grazing animals. • Presence of Norse apophytes associated with grazing/disturbance. • High charcoal influx.	High
Dairy	Short period of summer occupation. Milking of animals with products transported to the main farm almost immediately. Close to the main farm and with few structures, perhaps just a living quarters and a pen.	• Large numbers of coprophilous fungal spores (HdV-113 and HdV55a) associated with presence of animals during milking times. • High charcoal influx associated with fires for milk sterilization. • Presence of Norse apophytes associated with grazing/disturbance.	Moderate
Haymaking	Short period of summer occupation. Haymaking and collection of winter fodder are the main activities. Located in areas of limited pasture. Few structures, probably just a barn for collection of fodder.	• High influx of Poaceae pollen associated with haymaking. • Enhanced presence of pollen types associated with hayfield environments, such as Poaceae and *Ranunculus acris*-type. • Low charcoal influx given short occupation period.	Moderate