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Pollen, Plague & Protestants: The Medieval Monastery of Þingeyrar (Þingeyraklaustur) in Northern Iceland

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ABSTRACT
Until recently, Icelandic monasticism has been considered remote from European monasticism and that it had little impact upon medieval Icelandic society. Focussing upon a monastic site in northern Iceland (Þingeyraklaustur), palaeoecological data is utilised to explore the role of Icelandic monasticism with regard to land use in order to discern whether or not the aforementioned conventions hold true. In particular, are changes in land use associated with the eleventh century revival of European monasticism apparent in Iceland? Further consideration is given to changes in land use arising due to the challenges of plague, Reformation, and the prevailing climate regime for the Medieval period in Iceland. At Þingeyraklaustur, the clearance of *Betula* seems to be associated with the foundation of the monastery in the early twelfth century. The impact of plague is observed in the recovery of *Betula* during the fifteenth century. On both counts, events at Þingeyraklaustur reflect those encountered in the palaeoecological archive for monasteries elsewhere in Europe. Overall, there is a broad transition from dwarf shrub wetland to a grassland dominated landscape from the time of Iceland's settlement, through the monastic period (AD 1133–1551), and beyond the sixteenth century Reformation into the eighteenth century.

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Iceland; medieval; monasticism; land use; plague; reformation

Introduction

Þingeyrar, northern Iceland (Figure 1), is the former site of a medieval monastery (Þingeyraklaustur). This palynological study seeks to investigate whether or not ecological and socio-political changes are visible in the palaeoecological archive of the site for the term of the monastery (AD 1133–1551). This encapsulates change initiated by the monastery itself, e.g. land management practices, as well as challenges imposed upon it; either by society (e.g. Reformation), or by the environment (e.g. climate and volcanism). Of particular interest is whether or not the initiation of change under the aegis of the monastery, or responses to change imposed by external forces, reflect the experience of European monasteries.

It has been said that monasteries in Iceland were little more than retirement homes for the wealthy (Vésteinsson 2000); unique, eccentric, peripheral and remote from European monasticism. This ignores the fact that thirteen of Iceland's fourteen monasteries were founded between the eleventh and thirteenth centuries; concomitant with a well-documented renaissance in monasticism across Europe (Aston 2001; Bond 2004; Kristjánsdóttir 2017). Some obvious links between Iceland's monasteries and the world beyond its shores include the presence of foreign abbots (England) and the import of foreign goods such as alabaster (Midlands, England) and ceramics (Utrecht, Netherlands) (Kristjánsdóttir 2010a, 2017). However, more intellectual, philosophical and technical associations are apparent. Archaeological excavation at Skriðuklaustur (Figure 1) revealed a monastery that encapsulated all of the architectural elements that would be expected of an Augustinian monastery on the continent; church, cemetery, garden, well, Abbot's lodgings, chapter house, dormitory, refectory, kitchen, store rooms etc., as well as an infirmary. This latter feature, along with surgical instruments, evidence of medicinal plants (some introduced), and skeletal pathology (burials), infer an element of medical care; beyond that required for the aged and again, in keeping with the European monastic mission (Kristjánsdóttir 2008, 2010a, 2010b; Kristjánsdóttir, Larsson, and Åsen 2014). This evidence would suggest that Icelandic monasteries were very much a part of the wider Roman Catholic world.

The European revival in monasticism has been observed to have had a significant impact on land use (Aston 2000, 2001; Bond 2004; Hall 2006; Gilchrist 2014) through the development of mining, salt panning, water management (mill complexes, fishponds etc.), and centralised farms (granges) (Bond 2004; Hall 2006; Gilchrist 2014). Although the point was made in reference to Scotland, it may still stand that

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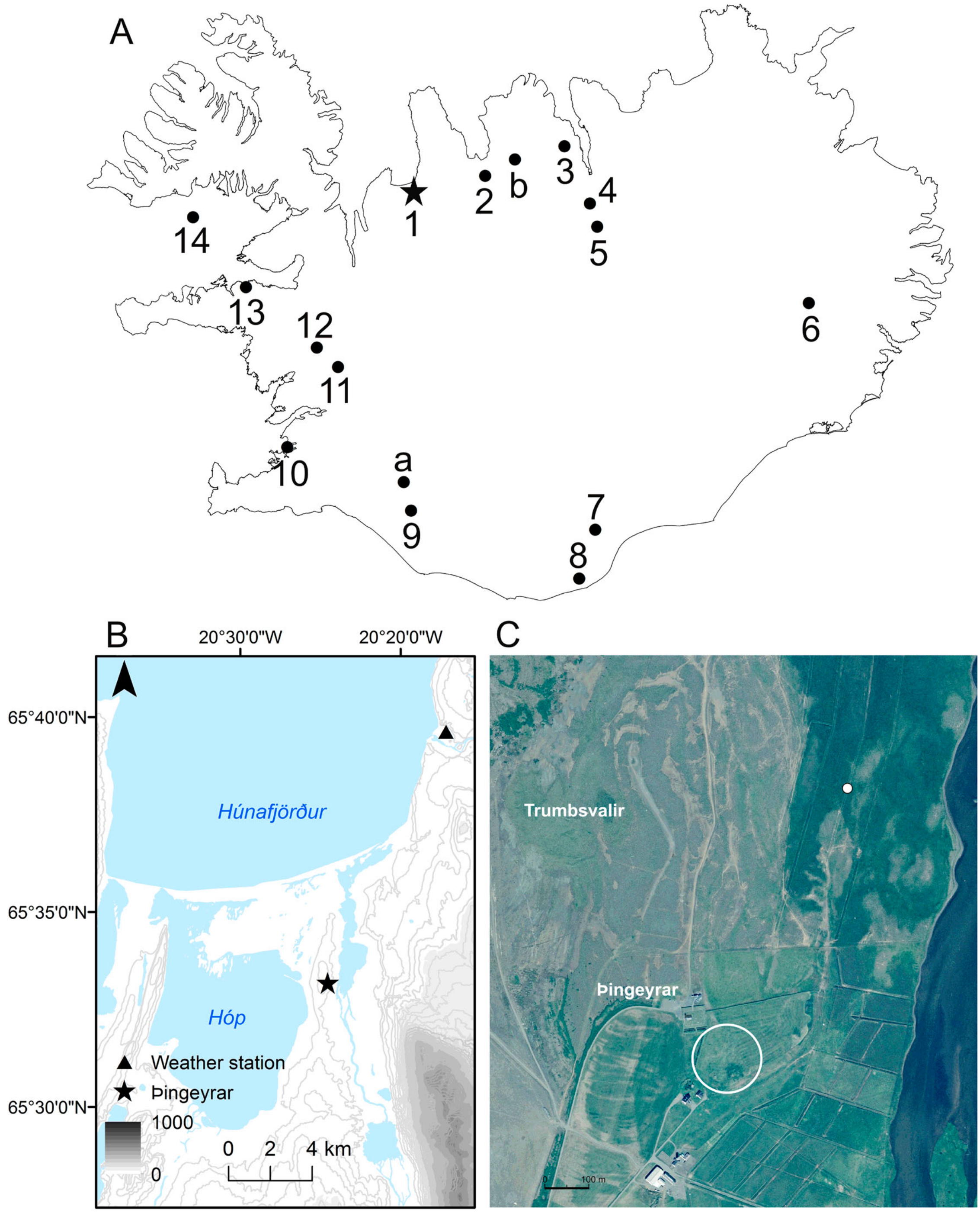

Figure 1. A) Monasteries of Iceland: 1) Þingeyraklaustur (AD 1133–1551), 2) Reynistaðarklaustur (AD 1295–1551), 3) Möðruvallaklaustur (AD 1295–1547), 4) Munkaþverárklaustur (AD 1155–1551), 5) Saurbæjarklaustur (AD 1200–1224), 6) Skriðuklaustur (AD 1493–1554), 7) Kirkjubæjarklaustur (AD 1186–1542), 8) Þykkvabæjarklaustur (AD 1168–1548), 9) Keldnaklaustur (AD 1193–1222), 10) Viðeyjarklaustur (AD 1226–1539), 11) Bæjarklaustur (1030–1049), 12) Hítardalsklaustur (AD 1166–1201/1237), 13) Helgafellsklaustur (AD 1184–1543), 14) Flateyjarklaustur (AD 1172–1184). a) Skálholt (1096) and b) Hólar (1106) represent the two episcopal seats of Iceland, south and north respectively. B) Þingeyrar and weather station (Blönduós). C) Þingeyrar and environs, site of monastic complex (encircled) and coring site (Image: Loftmyndir ehf 2006). For the interpretation of colour maps, please refer to the online version of this article.

in Europe, medieval monasticism initiated an agricultural revolution on a par with that of the Neolithic (Hall 2006). In accordance with God's will, European monasticism sought to bring order where there was disorder, to demonstrably impose an anthropogenic conformity upon (either real or contrived) desert and wilderness (Hoffmann 2014). Palaeoecological investigation has shown that across Europe, monastic orders were implicated in land clearance, the development of both arable and pastoral landscapes (Wimble, Wells, and Hodgkinson 2000; Noël et al. 2001; Lomas-Clarke and Barber 2004; Breitenlechner et al. 2010; Hjelle, Halvorsen, and Overland 2010; Stolz and Grunert 2010), and technological innovation, e.g. the introduction of new agricultural species (Tipping 1997). This may also be apparent in Iceland. Although there are late twelfth century references to cereal cultivation on the island of Viðey (Ólsen 1910) in south west Iceland, it is not until the foundation of the Augustinian monastery there in AD 1226 (Figure 1; Viðeyjarklaustur) that it appears in the palaeoecological record (Hallsdóttir 1993). This is interesting given that cereal cultivation was largely being abandoned elsewhere in south-western Iceland at that time (Riddell et al. 2018). This observation alone is sufficient to justify asking the question of what exactly was the relationship between monasticism and the Icelandic landscape? Were Iceland's monasteries importing new ideas on agriculture from Europe along with abbots, altars and architecture?

Þingeyrar: Assembly, Monastery and Farms

The *þing* (pron: thing) element of the place name Þingeyrar is indicative of a former site of political assembly (Karlsson 2000). Unfortunately, there is no written account of any political gathering at this place by which to support this inference. Furthermore, there is a longstanding belief that some of the archaeological remains at Þingeyrar are that of a *dómhringur* (law court) but this is looking increasingly unlikely. A geo-electrical (resistivity) survey has revealed the presence of a structure within the dómhringur and it is now proposed that the remains are of an early medieval church enclosure (Coolen and Mehler 2015; Kristjánsdóttir 2017).

The establishment of the Benedictine monastery at Þingeyrar was initiated, at the behest of the Archbishop Össur Sveinsson of Lund (Sweden), by the Bishop Jón Ögmundsson of Hólar (Jensson 2016). There are two dates for the foundation of Þingeyraklaustur, AD 1112 and AD 1133, with consensus favouring the latter date when its first Abbot, Vilmundur Þórólfsson, was ordained (Karlsson 2000; Kristjánsdóttir 2017). Following foundation, Þingeyraklaustur progressively began to acquire further properties, especially from the fourteenth century, in common with monasteries elsewhere in Iceland (Júlíusson 2014). By the sixteenth century, inventories reveal that there were 60 tenant farms across (Austur and Vestur) Húnavatnssýslur belonging to Þingeyraklaustur while the monastic landholding itself supported a relatively large body of livestock (Júlíusson 2014). Indeed, Þingeyraklaustur was possibly the wealthiest monastery in Iceland (Coolen and Mehler 2015). Over time, Þingeyraklaustur also gained fame as a literary centre, a place where regal, ecclesiastical and family sagas were written and transcribed (Kristjánsdóttir 2017). One of the most significant events in the history of the monastery occurred in the fifteenth century when two plague epidemics beset Iceland (AD 1402 and AD 1495) (Kristjánsdóttir 2017). However, it was in the following century that the Protestant Reformation effected the demise of the monastery at Þingeyrar (AD 1551). This witnessed the transfer of both the fixed and moveable assets of Þingeyraklaustur to the Danish state, subsequently administered by stewards thereof into the modern period (Karlsson 2000; Kristjánsdóttir 2017).

Recent archaeological investigation by the *Klaustur á Íslandi* (Monasticism in Iceland) project has revealed evidence of human activity at Þingeyrar prior to the establishment of the monastery (Kristjánsdóttir et al. 2016; Hjartarson et al. 2017). Material remains situated beneath the Hekla AD 1104 tephra include the presence of a possible smithy with floor layers incorporating charcoal and slag, a post hole, as well as human bone dated to c. AD 962–1040 (1030 ± 30 BP; Beta Analytic 473011, Hjartarson et al. 2017). A structure at nearby Trumbsvalir (Figure 1) was also present prior to the deposition of the Hekla AD 1104 tephra layer (Kristjánsdóttir and Gunnarsdóttir 2014). The precise nature of the relationship between Trumbsvalir and Þingeyraklaustur is unclear. Within a collection of medieval papers known as Diplomatarium Islandicum (DI I-XVI)), an inventory of AD 1525 identifies Trumbsvalir as an abandoned tenancy of the monastery (DI IX, p. 314), while it is absent from a later inventory for AD 1552 (DI XII, p. 451–454). Both inventories identify the adjacent farms of Geirastaðir (north) and Leysingjastaðir (south) as active tenancies of Þingeyraklaustur in the sixteenth century (DI IX, p. 314; DI XII, p. 451–454).

The Environment of Þingeyrar

Þingeyrar is situated approximately 13 km southwest of the town of Blönduós, Austur-Húnavatnssýsla, in northern Iceland (Figure 1). The ridge of Þingeyrar is orientated on a north–south axis bounded by the estuaries of Húnavatn and Hóp (east and west respectively). The underlying geology is comprised of tertiary basalts overlain by Holocene sand deposits (Thordarson and Hoskuldsson 2002). The northern end of the ridge terminates in an extensive gravel beach known as Þingeyrasandur which branches both east and west to confine the aforementioned estuaries as semi-saline lagoons (Guðmundsson 2007). The place name of Þingeyrar probably once applied to the entire area between the two estuaries but now refers specifically to the farm, church, and former monastery site, situated upon the summit of the ridge (Figure 1). The immediate vicinity of the farm is comprised of land converted from wetland into pasture via a network of drainage ditches. The primary land use is grazing for horses and hay fields. Progressing northwards along the ridge, the impact of soil erosion develops from considerable, to severe, to extreme (Arnalds et al. 2001); partially due to the dynamic coastal context

Table 1. Climate data for Blönduós, Austur-Húnavatnssýsla (Icelandic Meteorological Office 2018).

Recording period	1961–1990
Elevation (m a.s.l)	8
Avg. temp. °C tritherm	9.4
Avg. temp. °C July	8.7
Avg. temp. °C January	−2.5
Avg. pptn. mm yr^{-1}	458

rather than land use. Where vegetation survives, it is comprised of heathland, wetland and coastal plant communities. Nitrogen-fixing Alaskan lupin (*Lupinus nootkatensis*) has been introduced as a soil conservation measure (Ottósson, Sveinsdóttir, and Harðardóttir 2016). Land to the south consists of heath, wetland and modified wetlands, i.e. sheep pasture. Erosion is largely absent. Temperature and precipitation data for Austur-Húnavatnssýsla is available from a weather station at Blönduós (Figure 1; Table 1).

Methods and Materials

Historical Palaeoecology

In Iceland, palynology has been primarily utilised to discern the development of vegetation cover during the Holocene (e.g. Hallsdóttir 1995; Hallsdóttir and Caseldine 2005; Eddudóttir, Erlendsson, and Gísladóttir 2015, 2016, 2018; Eddudóttir 2016) or has focussed upon the impact of the human settlement on plant communities during the late ninth century (e.g. Einarsson 1962; Hallsdóttir 1987; Erlendsson 2007). Both represent prehistoric contexts (Friðriksson and Vésteinsson 2003), and with regard to the latter, rather than simply representing a marker of human colonisation, changes in the palynological record for Iceland may also shed light upon the allocation and utilisation of land in the medieval period (Vésteinsson 1998; Erlendsson et al. 2006). The present study acknowledges this potential but is situated within a context that allows palaeoecological data to be cross-referenced with the Icelandic historical archive, primarily Diplomatarium Islandicum (DI I-XVI) and Jarðabók (Magnússon and Vídalín 1926a). Difficulties with comparing the inexact chronologies of palaeoecological data with the refined timescales of documentary sources are recognised (Dumayne et al. 1995; Tipping 2004). However, in this instance, the application of tephrochronology proffers a degree of relief given that historic tephra isochrones can allow for direct comparison with the documentary archive, situated as they are, at fixed points in time (Thorarinsson 1967; Lomas-Clarke and Barber 2004).

Site Selection and Sampling

Potential sampling sites were identified via a field survey of the environs of the modern farm of Þingeyrar, either by test coring, or by cleaning the banks of existing ditches. Factors influencing the proximity of the sampling site to the monastic complex were the availability of an anaerobic context, an undisturbed sequence of sediments and a suite of potentially identifiable tephra layers. A core (c. 75 cm long) was extracted from a cleaned section (ISN93: N65° 33.594 W20°23.854) of ditch bank from within a wetland (now being developed as a plantation woodland) approximately 500 m from the remains of the monastic complex (Figure 1). The extracted core was protected in plastic guttering, wrapped in plastic film to inhibit contamination and moisture loss, and stored under cool conditions (4°C) prior to laboratory analysis.

Sedimentology

In order to detect influxes of minerogenic material into the sedimentary sequence, the entire column was measured at intervals of 1 cm for magnetic susceptibility (MS) with a Bartington MS2 meter and MS2E probe, with an enhanced resolution of 0.5 cm for the section 5 cm to 30 cm depth (Dearing 1994). Soil moisture content (SMC), dry bulk density (DBD) and organic matter (OM; by loss on ignition) were measured contiguously at 1 cm intervals. Dry weight was obtained by heating samples at 105°C for 24 hrs. with soil moisture calculated as percentage of dry soil weight (Burt 2004). DBD (g/cm^3) was calculated by dividing the dry weight of a sample by sample volume (1.2 cm^3) (Brady and Weil 1996). OM was measured by combusting 1.2 cm^3 sample of sediment at 550°C for 4 hrs. with loss on ignition (LOI) calculated according to Heiri, Lotter, and Lemcke (2001).

Age Determination

The chronological sequence is based upon tephrochronology. Tephra samples were extracted from all visible tephra horizons in the sediment profile, cleaned, sieved (63 µm), mounted, polished, and carbon-coated for analysis. MS detected a further tephra (23.5–25.5 cm), which was also sampled. To verify the sources of the tephra samples, their geochemistry was analysed at the University of Iceland using JEOL JXA-8230 electron probe micro-analyser (EPMA). Acceleration voltage was 15 kV, beam current 10 nA and beam diameter 10 µm. To verify consistency in analytical conditions, the standard A99 was measured before and after each session of analysis. The dataset was inspected for, and cleaned of, anomalies and analyses with sums of <96%. A radiocarbon date was sought from wood macro-fossils (1.5 mg) derived from a depth of 24.5–25.5 cm, situated within the tephra horizon at 23–25.5 cm depth. The arising material was analysed by ETH Zurich, Switzerland. Linear age-depth modelling of chronological data was performed with the Clam package in 'R' (Blaauw 2010).

Palynology

The volume (1–2 cm^3) of 36 individual pollen samples was determined by displacement in 10% HCl (Bonny 1972). One *Lycopodium clavatum* tablet (Batch no. 177745) was added to each sample as a control for the calculation of palynomorph concentrations (Stockmarr 1971). Pre-treatment consisted of rinsing samples in 10% HCl, 10% NaOH, acetolysis mixture, and sieving (150 µm) to remove coarse material (Moore, Webb, and Collison 1991). Dense media separation (LST fastfloat, 1.9 g/ml) was used to remove minerogenic material (Björck, Persson, and Kristersson 1978; Nakagawa et al. 1998). Pollen grains were slide-mounted with silicone oil of 12,500 cSt. viscosity (Moore, Webb, and Collison 1991). Using Moore, Webb, and Collison (1991) as the primary key, pollen counts were conducted using a microscope at 400–1000x magnification. At least 300 native land pollen (total land pollen, TLP) were counted for each sub-sample. Where Cyperaceae (sedge) pollen was overly dominant, counting was continued until a minimum of 100 pollen, excluding Cyperaceae, was attained. All Poaceae (grass) pollen were evaluated as potential cereal-type, i.e. mean grain diameter >37 µm, annulus diameter >8 µm (Andersen 1979). All *Betula* (birch) pollen grains were measured in order to distinguish between *Betula nana* and *Betula pubescens* as a means of differentiating dwarf birch heath from birch woodland (Mäkelä 1996; Caseldine 2001; Erlendsson and Edwards 2009). Following Karlsdóttir (2014), the mean size of *B. nana* pollen grains is 20.4 µm while that of *B. pubescens* is 24.2 µm. Pteridophyte spores, microscopic charcoal and spores from coprophilous (dung-loving) fungi (van Geel et al. 2003; Cugny, Mazier, and Galop 2010) were also recorded. Both charcoal and coprophilous fungi are recognised environmental proxies for human activity and the presence of livestock in Iceland from the time of colonisation (Edwards, Erlendsson, and Schofield 2011). Count data were entered into TILIA (version 2.0.41) and subjected to a Total Sum of Squares Analysis (CONISS), producing a stratigraphically constrained dendrogram to aid zonation (Grimm 2011). Plant nomenclature follows Kristinsson (1986). Pollen and spore taxonomy follows Moore, Webb, and Collison (1991) but is amended to better reflect the Icelandic flora (Erlendsson 2007).

Ordination Analysis

Ordination analyses were utilised in order to better understand the relationship between past pollen assemblages arising within the immediate vicinity of the sample site. Detrended Correspondence Analysis (DCA) revealed a linear response of 1.5925 on the first axis of the pollen dataset (Hill and Gauch 1980). Principal Component Analysis (PCA) was therefore applied to Hellinger transformed data consisting of pollen taxa with percentages >1%. Both DCA and PCA were applied using the vegan package in 'R' (Oksanen et al. 2016).

Results

Chronology

With reference to Figure 2 and Table 2, the two lowermost tephra layers in the stratigraphy have been identified as Hekla 4 (47.5 cm) and Hekla 3 (38.5 cm) (Dugmore et al. 1995). A Veiðivötn tephra is interpreted here as the Landnám Tephra Layer (LTL) AD 877 ± 1 (Schmid et al. 2017) due to its chemical composition (Table 2) and stratigraphic position (25.5 cm) in relation to the Hekla 3 and Hekla AD 1104 (20.5 cm) tephra layers (Eiríksson et al. 2000). The uppermost tephra (6 cm) is considered to be the Hekla AD 1766 tephra due to its geochemistry and dispersal range (Thorarinsson 1967; Sverrisdottir 2007). These findings are consistent with other tephra sequences identified in palaeoenvironmental studies from northern Iceland, e.g. Steinberg, Bolender, and Damiata (2016) and Möckel, Erlendsson, and Gísladóttir (2017).

The radiocarbon data is presented (Table 3, Figure 2) but it has not been incorporated into the chronological sequence as it does not conform with

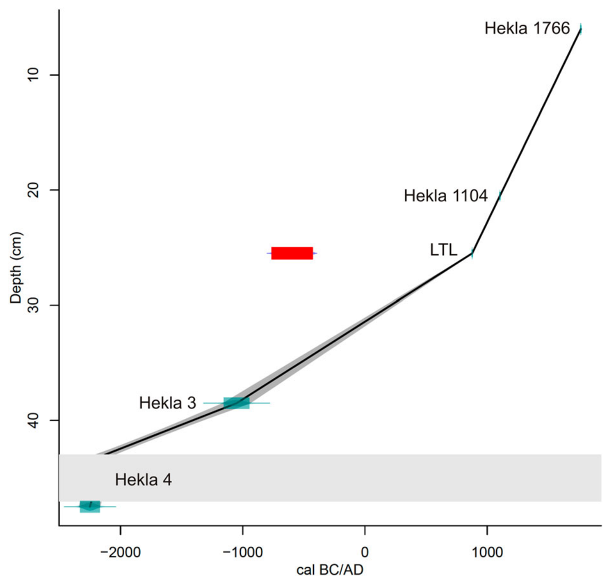

Figure 2. Age-depth model for the Þingeyrar core. Blue horizontal lines indicate the depth of the tephra layers and the red horizontal line indicates the radiocarbon date. The horizontal band denotes the thickness of the Hekla 4 tephra layer. For the interpretation of references to colour in this chart, please refer to the online version of this article.

Table 2. Major elements (wt%) of glass shards in tephra layers observed in Þingeyrar profile.

Profile and depth (cm)	SiO_2	TiO_2	Al_2O_3	FeO	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	Total
THING 6–7	60.17	1.14	15.36	9.86	0.25	1.45	5.15	3.17	1.61	0.48	98.63
THING 6–7	59.86	1.20	15.36	9.83	0.24	1.54	5.11	4.18	1.49	0.34	99.15
THING 6–7	59.80	1.17	15.23	9.90	0.34	1.57	5.05	4.31	1.59	0.38	99.35
THING 6–7	59.22	1.36	15.39	9.95	0.28	1.82	5.55	3.89	1.55	0.50	99.51
THING 6–7	58.57	1.38	15.48	10.00	0.25	1.95	5.56	4.17	1.52	0.56	99.44
THING 6–7	57.94	1.45	15.27	10.62	0.29	2.06	5.92	4.06	1.52	0.61	99.74
THING 6–7	57.90	1.54	15.49	10.62	0.24	1.99	5.72	4.02	1.43	0.57	99.52
THING 6–7	57.86	1.49	15.35	10.68	0.27	2.08	5.48	3.47	1.40	0.61	98.69
THING 6–7	57.83	1.49	15.27	10.45	0.24	1.97	5.81	3.75	1.43	0.65	98.89
THING 6–7	57.66	1.53	15.07	10.40	0.23	2.06	5.73	4.08	1.53	0.64	98.93
THING 6–7	57.64	1.55	14.89	10.76	0.26	2.06	5.80	3.77	1.51	0.63	98.87
THING 6–7	57.57	1.42	15.34	10.52	0.20	2.08	5.59	3.97	1.54	0.59	98.83
THING 20–21	72.17	0.22	14.59	3.11	0.12	0.10	1.99	4.03	2.67	0.02	99.02
THING 20–21	72.15	0.21	14.42	3.18	0.11	0.10	2.06	4.10	2.60	0.08	99.01
THING 20–21	71.90	0.22	14.28	3.24	0.10	0.12	1.92	4.29	2.42	0.06	98.55
THING 20–21	71.87	0.18	14.26	3.13	0.11	0.10	1.92	4.12	2.74	0.05	98.48
THING 20–21	71.80	0.21	14.07	3.21	0.13	0.12	1.92	2.66	2.69	0.04	96.85
THING 20–21	71.77	0.19	13.97	3.26	0.11	0.12	1.97	2.88	2.50	0.00	96.78
THING 20–21	71.75	0.20	14.29	3.09	0.14	0.09	1.85	4.16	2.61	0.06	98.24
THING 20–21	71.51	0.17	14.41	3.22	0.10	0.09	1.96	4.36	2.67	0.01	98.50
THING 20–21	71.39	0.17	14.18	3.23	0.11	0.12	1.91	3.34	2.70	0.05	97.20
THING 20–21	71.14	0.26	14.07	3.19	0.10	0.12	1.89	3.09	2.58	0.02	96.46
THING 25–25.5	49.64	1.76	13.74	12.02	0.20	6.78	11.72	2.40	0.24	0.15	98.65
THING 25–25.5	50.95	1.69	13.90	11.73	0.22	6.31	10.88	2.68	0.32	0.12	98.79
THING 25–25.5	49.50	1.72	13.60	11.99	0.23	6.99	11.90	2.28	0.20	0.20	98.60
THING 25–25.5	48.97	1.71	13.90	12.05	0.22	7.11	12.01	2.26	0.20	0.19	98.61
THING 25–25.5	49.24	1.70	13.92	12.06	0.20	7.08	11.76	2.23	0.21	0.17	98.57
THING 25–25.5	49.37	1.74	13.72	11.89	0.21	7.12	11.80	2.34	0.20	0.19	98.58
THING 25–25.5	48.92	1.79	13.61	12.33	0.22	6.86	11.89	2.35	0.20	0.18	98.36
THING 25–25.5	49.44	1.74	13.78	12.25	0.23	6.96	11.64	2.47	0.21	0.19	98.91
THING 25–25.5	49.57	1.76	13.93	11.94	0.22	7.07	11.67	2.37	0.18	0.16	98.87
THING 25–25.5	49.15	1.67	13.82	11.81	0.21	7.45	12.16	2.35	0.18	0.15	98.94
THING 25–25.5	49.85	1.85	13.87	12.09	0.20	6.81	11.45	2.37	0.24	0.20	98.93
THING 25–25.5	50.11	1.76	13.87	11.92	0.20	7.08	11.89	2.48	0.22	0.17	99.69
THING 25–25.5	49.19	1.75	13.79	12.31	0.21	6.97	12.04	2.33	0.19	0.16	98.94
THING 25–25.5	49.55	1.89	13.70	12.50	0.20	6.86	11.80	2.34	0.19	0.12	99.15
THING 25–25.5	49.32	1.71	13.85	12.08	0.20	7.10	11.88	2.40	0.19	0.13	98.86
THING 38–38.5	73.91	0.13	13.27	2.02	0.12	0.02	1.31	2.85	2.79	0.00	96.42
THING 38–38.5	72.12	0.22	14.47	3.06	0.10	0.14	2.03	4.36	2.47	0.05	99.03
THING 38–38.5	66.02	0.50	15.18	6.27	0.21	0.50	3.70	3.06	1.92	0.07	97.43
THING 38–38.5	65.99	0.41	15.43	5.89	0.14	0.40	3.27	3.04	2.06	0.10	96.71
THING 38–38.5	64.05	0.87	16.04	6.82	0.19	1.21	4.24	4.01	1.65	0.31	99.40
THING 38–38.5	63.69	0.62	15.12	7.74	0.21	0.79	3.96	4.21	1.86	0.23	98.44
THING 38–38.5	63.62	0.96	15.73	7.00	0.22	1.26	4.32	4.15	1.62	0.26	99.13
THING 38–38.5	63.49	0.65	15.62	8.12	0.22	0.84	4.33	2.87	1.74	0.27	98.15
THING 44.5–45.5	75.39	0.07	13.43	1.93	0.10	0.02	1.29	3.10	2.83	0.03	98.19
THING 44.5–45.5	75.13	0.12	13.42	1.95	0.09	0.01	1.29	4.41	2.78	0.00	99.20
THING 44.5–45.5	74.94	0.13	13.34	1.89	0.14	0.01	1.30	2.69	2.84	0.01	97.28
THING 44.5–45.5	74.51	0.13	13.21	2.02	0.08	0.01	1.36	3.18	2.88	0.00	97.37
THING 44.5–45.5	74.40	0.10	13.26	2.06	0.09	0.01	1.39	4.25	2.84	0.00	98.40
THING 44.5–45.5	74.32	0.10	12.92	1.94	0.07	0.02	1.28	2.95	2.71	0.00	96.31
THING 44.5–45.5	74.29	0.09	13.22	1.95	0.09	0.02	1.28	4.10	2.74	0.01	97.79
THING 44.5–45.5	74.21	0.10	13.37	1.92	0.06	0.02	1.30	2.84	2.76	0.01	96.59
THING 44.5–45.5	73.99	0.09	13.30	2.00	0.10	0.01	1.38	2.65	2.70	0.01	96.23
THING 44.5–45.5	73.78	0.12	13.46	2.00	0.08	0.00	1.28	2.91	2.72	0.01	96.37
THING 44.5–45.5	73.70	0.13	13.31	2.04	0.10	0.01	1.31	4.04	2.76	0.02	97.42
THING 44.5–45.5	73.57	0.07	13.34	2.02	0.09	0.00	1.28	4.16	2.80	0.00	97.34

the tephrochronological elements of the age-depth model. This could be attributed to a hiatus in the stratigraphy. However, both visual assessment of the sediment core and a consideration of sedimentary properties (Figure 3) presents a clear continuity in strata development between H4 (43 cm) and H1 (21 cm).

Palynology and Sedimentology

Interpretation of pollen data is based primarily upon pollen percentages (Figure 4) as a means of ascertaining the relative proportions of pollen and spore taxa within a sample (Birks and Birks 1980). As percentage values are co-dependent, e.g. high values in Cyperaceae may

Table 3. Radiocarbon date from the Þingeyrar core.

Sample	Depth (cm)	^{14}C Date (BP)	Error 1σ	$\delta\,^{13}C$ (‰)	Calibrated age (BC) 2σ	Weight (mg)	Material
Þingeyrar (ETH-82940)	24.5–25.5	2463	35	−30.2	762–429	1.5	Wood

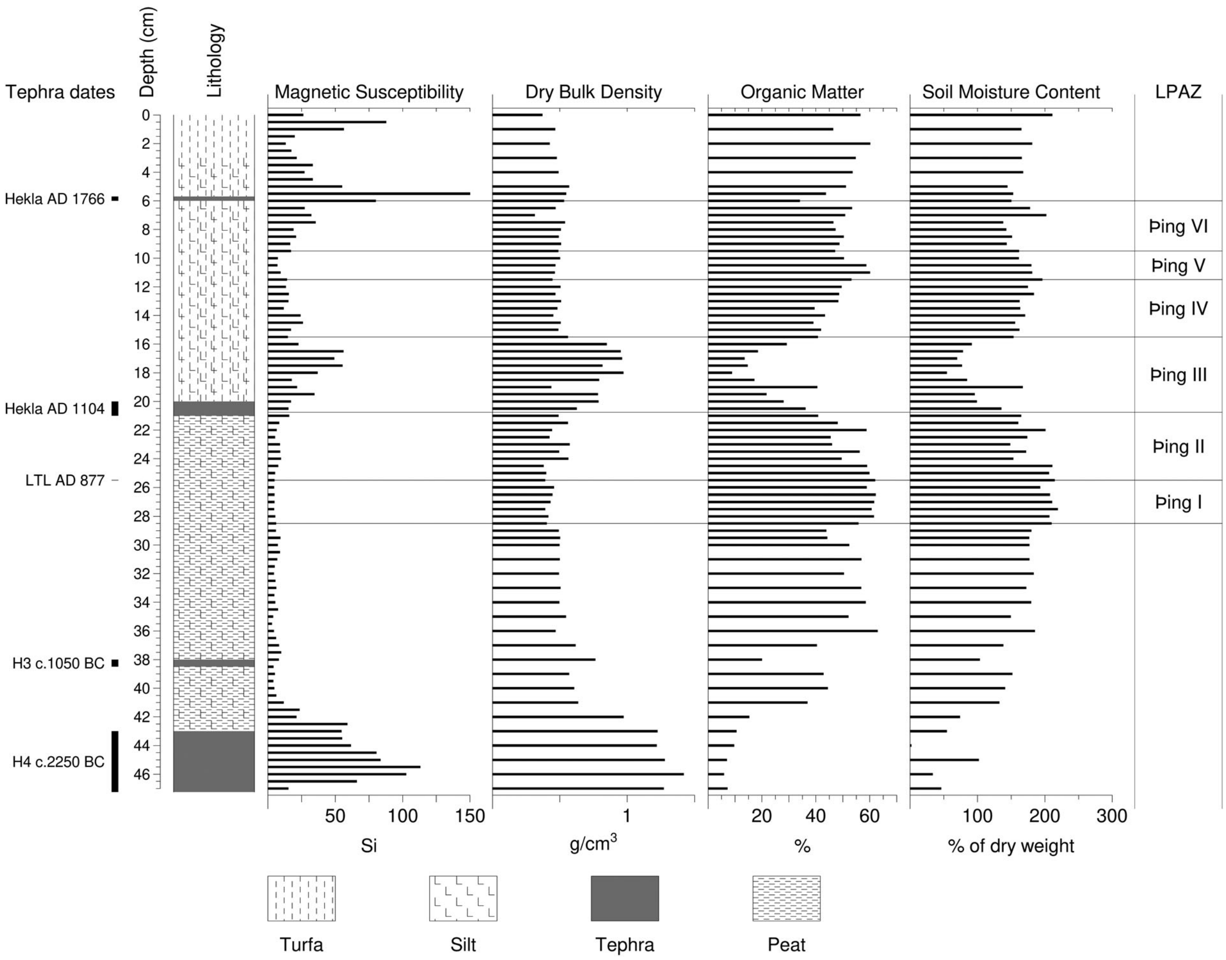

Figure 3. Sediment properties of the Þingeyrar core (MS, DBD, SMC, OM).

suppress values for other taxa, data are presented (Figure 5) that exclude Cyperaceae from the percentage calculation in order to aid interpretation (Moore, Webb, and Collison 1991). Alternative clarification can also be sought with reference to absolute data expressed as pollen concentration (Figure 6). The palynological data are divided into six Local Pollen Assemblage Zones (LPAZ; Þing I-VI) based upon the visual examination of the various datasets and consultation with the dendrogram (Figure 4). Interpolated dates are derived from the age-depth model (Figure 2). Corprophilous fungi encompasses *Sordaria*-type (HdV 55A), *Sporomiella-type* (HdV 113) and *Delitschia* spp. (Figures 4–6).

Þing I (Figure 4; 28.5–25.5 cm; AD c. 432 to 877) infers an environment where *Betula* and Cyperaceae are co-dominant (60% and 40% respectively). Based upon *Betula* pollen grain size (Figure 8), it is thought that *Betula nana* is the principal species concerned and *Betula* is henceforth considered to mostly represent *B. nana* (Mäkelä 1996; Caseldine 2001; Erlendsson and Edwards 2009; Karlsdóttir 2014). Of the other taxa, *Salix* (willows) is prominent (5%) along with Pteropsida (monol.) indet. (ferns; 5%) and Poaceae (6%). These values are reflected in Cyperaceae-excluded percentages and pollen concentrations (Figures 5 and 6). There are no significant alterations to the sedimentary data (Figure 3).

Þing II (Figure 4; 25.5–20.75 cm; AD 877 to 1104) presents an environment where *Betula* and Cyperaceae values are gradually dropping (to <40% and <30% respectively). This decline is also mirrored by *Salix* (<5%), perhaps more notably given the decline in pollen concentration for this taxon (Figure 6), from ~4000 to ~1000 pollen grains/cm^3. *Angelica* (Angelicas), Brassicaceae (crucifers), *Filipendula ulmaria* (Meadowsweet) and *Vaccinium*-type (e.g. Bilberry) appear similarly affected. Ericales (encompassing Ericaceae and Empetraceae) and *Empetrum nigrum* (Crowberry) values are increasing from <1% up to 5% and 6% respectively. Poaceae values remain relatively consistent. Overall, similar trends are also observed in Cyperaceae-excluded percentages and pollen concentrations (Figures 5 and 6). Sedimentary trends (Figure 3) show a progressive decline in SMC and OM values with an increase in DBD and MS values.

Þing III (Figure 4; 20.75–15.5 cm; AD 1104 to c. 1332) witnesses a considerable reduction in *Betula* (5%) while *Salix*, Ericales, *Empetrum nigrum* and *Angelica* fall to zero values. There is an increase in Poaceae values

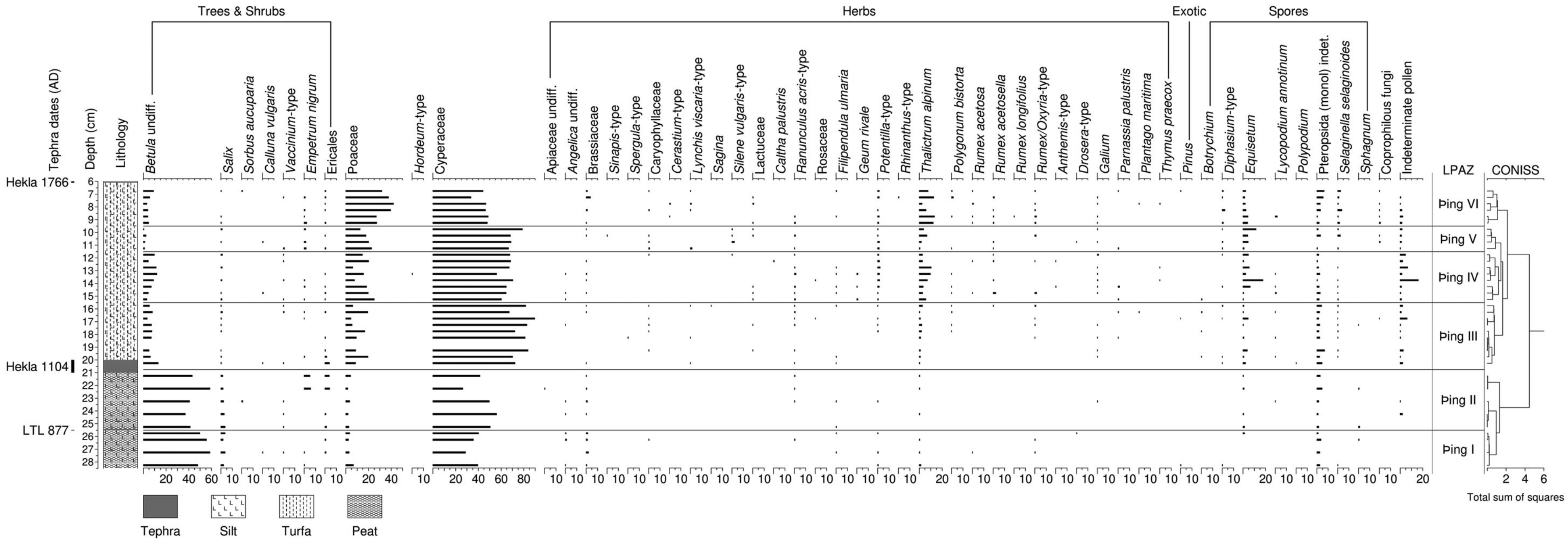

Figure 4. Pollen percentage diagram for the Þingeyrar core with LPAZ dendrogram.

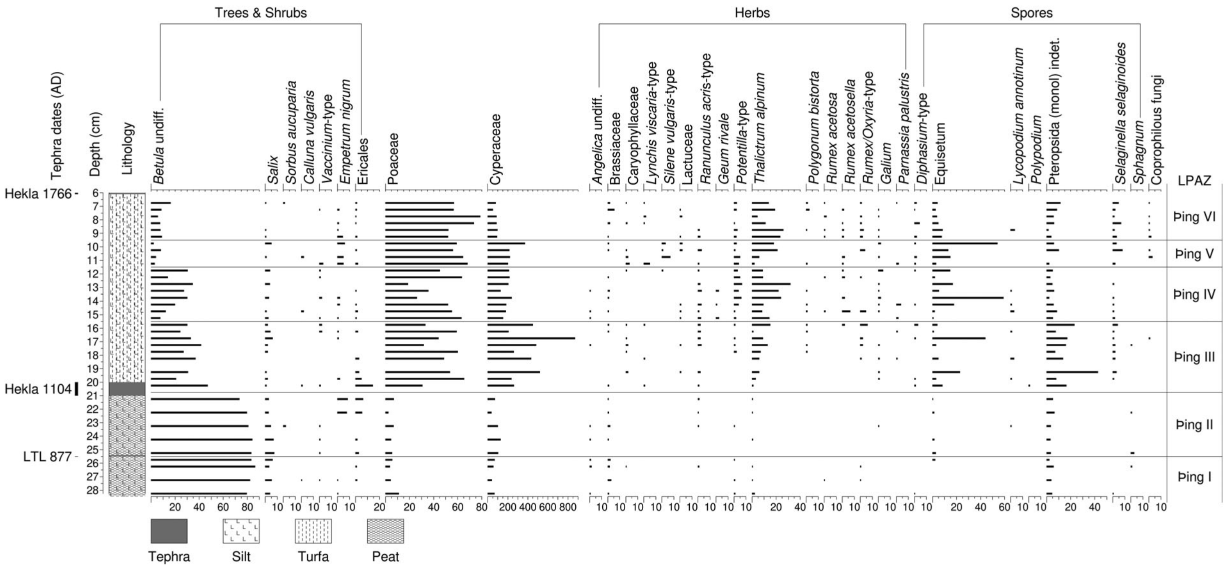

Figure 5. Pollen percentage diagram for the Þingeyrar core for all taxa and species ≥1% TLP and with Cyperaceae excluded from the percentage calculation.

(20%) and Cyperaceae becomes almost completely dominant (90%). A consistent signal for *Selaginella selaginoides* (Lesser clubmoss) arises, *Equisetum* (horsetail) increases (6%) and there is a tentative increase in the prominence of *Thalictrum alpinum* (Alpine meadow rue; 5%). A greater variety of herbaceous species and taxa also begin to be recorded for this LPAZ along with coprophilous fungi (16.75 cm). Similar trends are apparent in Cyperaceae-excluded percentages and pollen concentrations (Figures 5 and 6). Sedimentary data (Figure 3) display the lowest values for OM and SMC and corresponding peaks in values for DBD and MS.

Þing IV (Figure 4; 15.5–11.5 cm; AD c. 1332 to c. 1515) reveals a recovery of *Betula* (maximum 20%) at the expense of Poaceae (minimum 10%) and Cyperaceae (briefly falling to 55%). Of the grasses, a single *Hordeum*-type pollen is present (13.25 cm). *Potentilla*-type (cinquefoils; 2%), *Thalictrum alpinum* (12%) and *Equisetum* (19%) are increasingly prominent and the signal for *Rumex* spp. (sorrels) is stronger than in previous LPAZ. Similar trends can be seen in Cyperaceae-excluded percentages and pollen concentrations (Figures 5 and 6). Sedimentological data reveals a recovery in SMC with values similar to those of the pre-Landnám LPAZ (Þing I). OM values are increasing while those of DBD and MS decline (Figure 3).

Þing V (Figure 4; 11.5–9.5 cm; AD c. 1515 to c. 1606) suggests another significant reduction in *Betula* (<5%) and a corresponding increase in Poaceae (maximum 20%). A slight recovery in *Empetrum nigrum* values is apparent (2%). Cyperaceae and *Equisetum* remain fairly

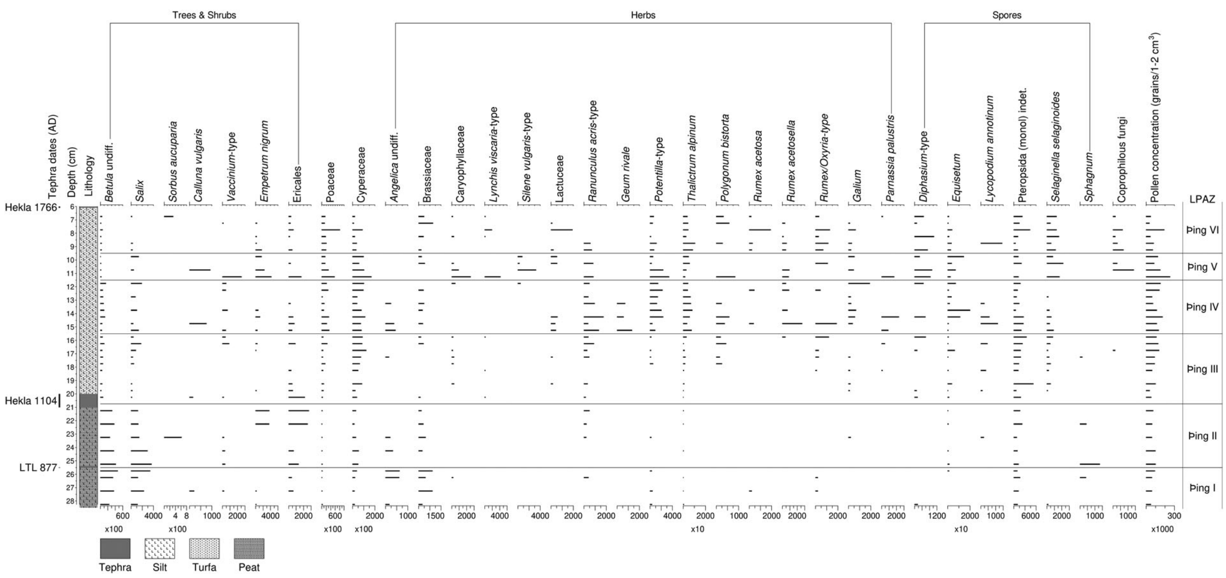

Figure 6. Pollen concentration diagram for the Þingeyrar core for all taxa and species ≥1% TLP.

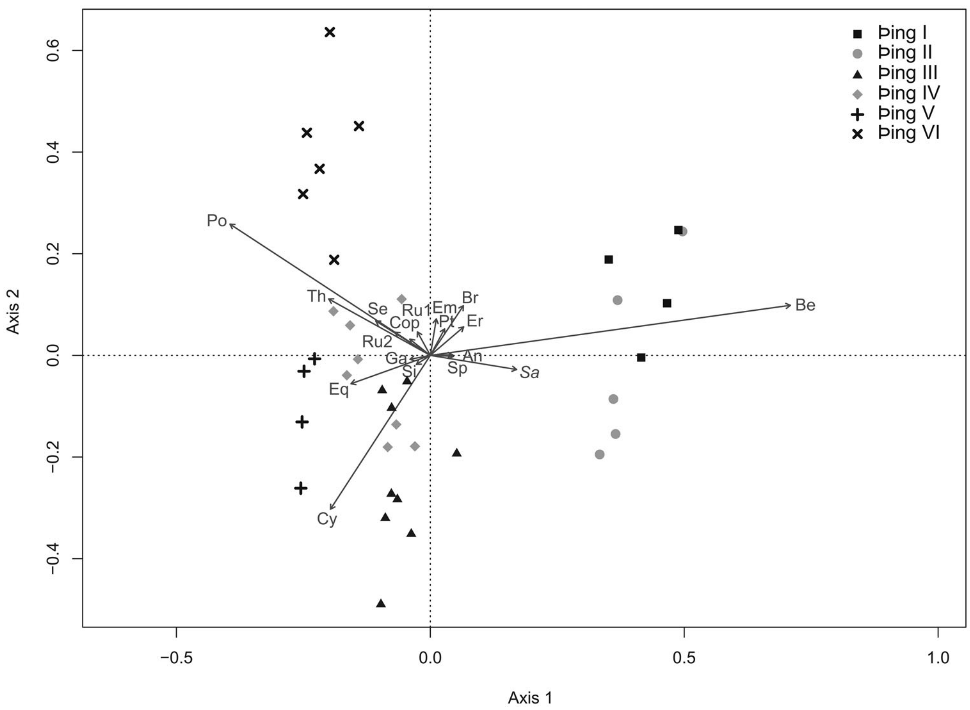

Figure 7. Principal component analysis (PCA). Note that only a selection of taxa and species are presented; An (*Angelica* undifferentiated), (*Betula* undifferentiated), Br (Brassicaceae), Cop (Coprophilous fungi), Cy (Cyperaceae), Em (*Empetrum nigrum*), Er (Ericales), Eq (*Equisetum*), Ga (*Galium*); Po (Poaceae), Ru1 (*Rumex acetosa*), Ru2 (*Rumex acetosella*), Sa (*Salix*), Se (*Selaginella selaginoides*), Si (*Silene vulgaris*-type), Sp (*Sphagnum*), Th (*Thalictrum alpinum*).

stable with the PCA intimating that Cyperaceae remains dominant (Figure 7). Coprophilous fungi are present (from 10.75 cm). These patterns are mirrored in Cyperaceae-excluded percentages and pollen concentrations (Figures 5 and 6). MS values show a slight decline while those of DBD remain relatively stable (Figure 3). OM and SMC values (Figure 3) are akin to pre-Landnám values (Þing I) before declining slightly.

Þing VI (Figure 4; 9.5–6 cm; AD c. 1606 to 1766) observes Poaceae reach its maximum value (44%) at the expense of Cyperaceae (minimum 30%); a decline mirrored by *Equisetum* (<5%). PCA (Figure 7) reveals that Poaceae is now dominant. *Thalictrum alpinum* (maximum 15%) reasserts its presence and there is a stronger manifestation of *Rumex* spp., *Selaginella selaginoides* (5%) and *Diphasium*-type (e.g. *Diphasium alpinum*; 3%) compared with previous LPAZ. The presence of coprophilous fungi is also more consistent than before. Of final note is the slight recovery of *Betula* (10%). Cyperaceae-excluded percentages and pollen concentrations demonstrate comparable trends (Figures 5 and 6). Sedimentary data (Figure 3) identify a relative stability in SMC and OM, with both increasing toward the onset of the eighteenth century (7–6 cm). DBD values remain fairly stable while an increase in MS is associated with the Hekla AD 1766 tephra.

Ordination Analysis

PCA (Figure 7) verifies the pollen zonation (Figures 4–6) and the transition from pre-Landnám vegetation cover (Þing I), to the decline in *Betula* from Landnám (Þing II) from the late ninth century, to the establishment of an open landscape dominated by Cyperaceae (Þing III) in the early twelfth century. Open habitats persist with a shift toward Poaceae from Cyperaceae inferred for the fourteenth century (Þing IV). Cyperaceae reasserts its presence (Þing V) in the sixteenth century before ultimately submitting to Poaceae, by the eighteenth century. Apophytes and coprophilous fungi are also a strong feature of the latter pollen zone (Figure 8).

Discussion

The following interpretation is set within a climatological framework that in time came to be dominated by what is known as the Little Ice Age (LIA) (Mann 2002a) c. AD 1500–1900 and preceded by the Medieval Climatic Optimum (MCO or Medieval Warm Period) from c. AD 900 (Mann 2002b). Palaeoecological data from the Greenland Sea (north of Iceland) suggests that the MCO spanned the period AD 800–1350 followed by the LIA which persisted until AD 1900 (Eiríksson et al. 2000). This corresponds broadly with lacustrine palaeoenvironmental data from the Icelandic highlands (Larsen et al. 2012). A review of palaeoecological and historical data infers a more nuanced interpretation of the LIA in Iceland, subsequently proposed to have spanned the period c. AD 1250–1900 and broadly separated into two phases (Ogilvie and Jónsson 2001). The earlier phase was relatively mild but punctuated by short periods of harsh

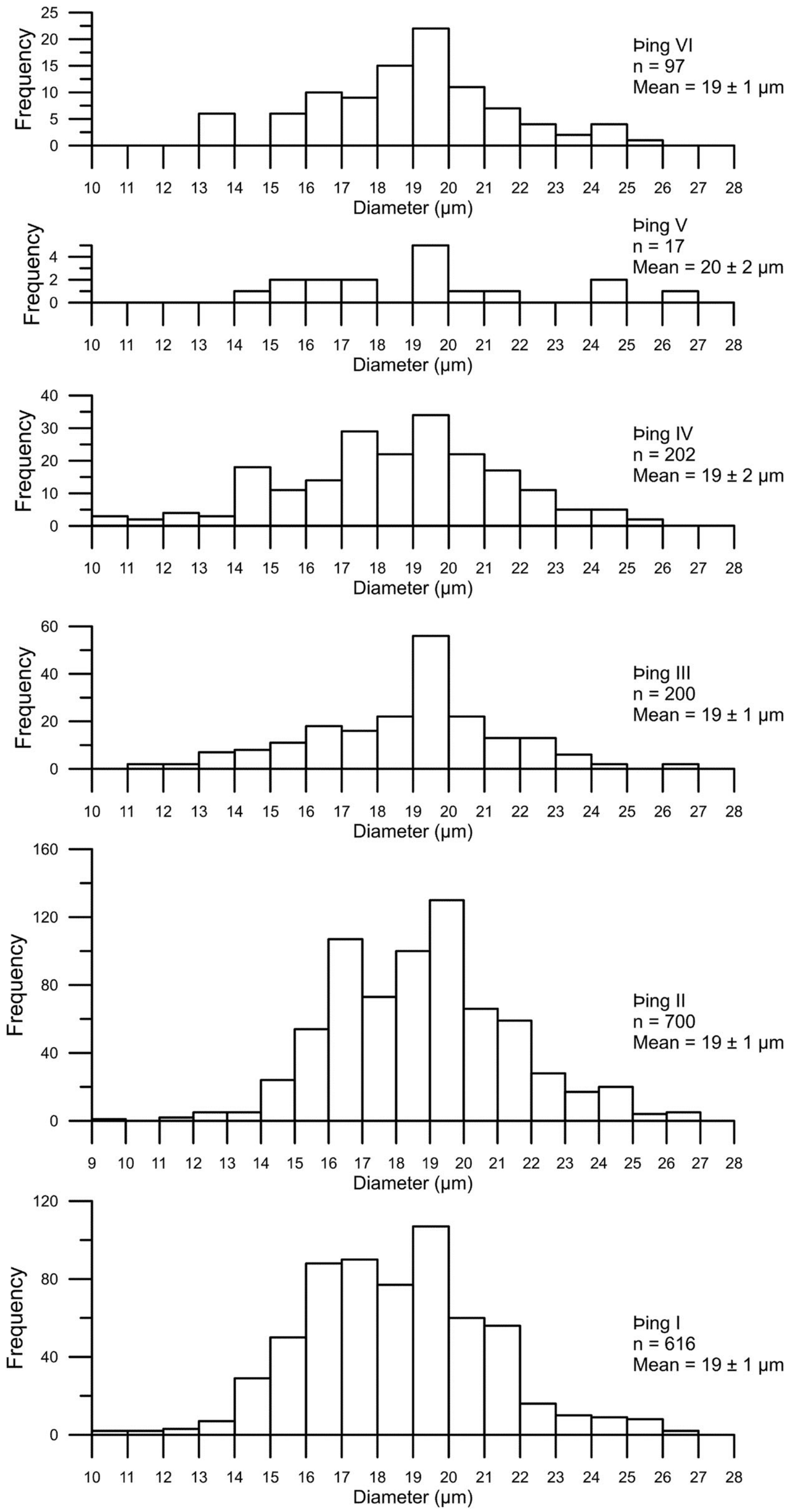

Figure 8. Measured diameters (µm) of *Betula* pollen grains for Þing I-VI.

climate until c. AD 1500 whereupon the incidence of severe conditions increased before abating c. AD 1900. Both the settlement of Iceland (Landnám) and the foundation of Þingeyraklaustur occurred within the span of the MCO and negative impacts upon vegetation at Þingeyrar for these periods are more likely to be anthropogenic in origin (cf. Eddudóttir et al. 2016; Tinganelli et al. 2018).

Þingeyrar: Pre-Landnám (Þing I, c. AD 432–877)

The earliest data sequence represents a pre-Landnám context dominated by *B. nana* and Cyperaceae (Figures 4–7); essentially a wetland. It is unlikely that any habitats in Iceland today are unmodified by human activity and are probably unrepresentative of habitats found in Iceland prior to human settlement. However, it is possible that this vegetation community could have been akin to a Boreal black sedge-brown moss fen (Icelandic vegetation classification: D4.162); a *B. nana* dominated wetland habitat that is still found at Þingeyrar (Ottósson, Sveinsdóttir, and Harðardóttir 2016). It is perhaps testament to the resilience of *B. nana* that it has apparently never disappeared entirely from Þingeyrar in the last 1000 or so years despite pressure from humans (fuel), coastal context (Thórsson et al. 2007; Möckel, Erlendsson, and Gísladóttir 2017), volcanic eruptions (Eddudóttir, Erlendsson, and Gísladóttir 2017) and climate (De Groot, Thomas, and Wein 1997).

Þingeyrar: Landnám (Þing II, c. AD 877–1104)

The arrival of people at Þingeyrar is muted (Figures 4–6) compared to the Landnám signal found elsewhere in Iceland, e.g. Reykholtsdalur, Reykjavík, Mosfellsdalur, Grímsnes, Skálholt and Stóra-Mörk (Einarsson 1962; Hallsdóttir 1987; Vickers et al. 2011; Riddell et al. 2018; Erlendsson et al. 2018) as well as within Austur-Húnavatnssýsla (Eddudóttir et al. 2016; Tinganelli et al. 2018). This is not unprecedented (Erlendsson 2007; Erlendsson, Edwards, and Buckland 2009) and spatial complexity must be recognised (Streeter et al. 2015). In this instance, the simplest explanation is that the sample site is relatively remote from the centres of human activity at Þingeyrar and Trumbsvalir (Figure 1) during the Landnám period. The absence of charcoal throughout the sedimentary record emphasises this, as does the intermittent and late arrival of coprophilous fungi.

B. nana is not a plant that is particularly favoured by livestock as fodder, only ever grazed during the winter months; if at all (Hejcman et al. 2016). It is possible therefore that its decline arises as a result of settlers directly clearing scrub in order to increase grazing area or to harvest fuel (or both). Firm evidence (macro-fossils) for the use of *Betula* spp. as a source of fuel comes from the hearth, floors and midden of a Viking Age farmstead at Vatnsfjörður, north west Iceland (Mooney 2009). Even during the MCO, it has been estimated that a Viking Age household in Iceland might require a minimum area of c. 11 m^2 per day in order to supply its fuel (cooking and heat) needs (Trbojevic, Mooney, and Bell 2011).

Livestock remain implicated given the decline in *Salix*, a plant that is very palatable to domestic animals (Hejcman et al. 2016), and the rise in values for the comparatively unpalatable *Empetrum nigrum* (Knud et al. 2000). Indeed, a subtle transition to an *Empetrum nigrum* dominated wetland appears to be underway in the short term (Figure 4; c.11th century).

Þingeyraklaustur: Foundation (Þing III, c. AD 1104–1332)

In contrast to the initial colonisation of Þingeyrar, the arrival of the monastery in the landscape clearly had an impact on the character of the vegetation and environment. Indeed, many of the signals one would expect of Landnám are present (Figures 4–7), i.e. the development of a landscape increasingly characterised by open wetland (Cyperaceae) and grassland (Poaceae and *Selaginella selaginoides*), the signal for apophytic plants is stronger (e.g. Caryophyllaceae, *Ranunculus acris*-type, *Galium*, and *Rumex* spp.) and the, albeit tentative, presence of coprophilous fungi. Soil conditions are also altered (Figure 3). Considering that there are two dates given in the historical archive for the establishment of the monastery at Þingeyrar, these environmental changes would be more consistent with the earlier date of AD 1112. It is therefore worth bearing in mind that the construction and occupation of Þingeyraklaustur probably began decades before its formal inauguration in AD 1133 (and hence the variance in dates regarding foundation). European parallels of such environmental change can be drawn with respect to palaeoecological evidence from the monasteries of Abbeyknockmoy (Ireland), Melrose (Scotland), Furness (England), Annecy (France) and St. Georgenberg-Fiecht (Austria), all implicated in the development of pastoral landscapes during the twelfth century (Wimble, Wells, and Hodgkinson 2000; Noël et al. 2001; Lomas-Clarke and Barber 2004; Breitenlechner et al. 2010; Tipping 2010). It is a further drop in *Salix* and the incidence of coprophilous fungi from the late thirteenth century (Figures 4–6, 16.75 cm) that perhaps intimates the agent of overall change at Þingeyrar, i.e. livestock. Sustaining livestock at a monastery may either be linked with food or manuscript production (or both). Zooarchaeological evidence from Skriðuklaustur revealed that a relatively high number of the cattle bones found there were of neonatal or very young calves (c. 13%) suggesting an emphasis on dairy farming or vellum (calfskin) production (Hamilton-Dyer 2010).

Another factor worth considering is that the construction of a monastery at Þingeyrar is likely to have made some demand upon the landscape in its immediate vicinity, most obviously for fuel for cooking and warmth. This may be apparent in the retreat of *B. nana* (Figures 4–6), a feature also observed in the pollen record for Viðeyjarklaustur (Figure 1) at the time of its establishment c. 1226 (Hallsdóttir 1993). Furthermore, as charcoal is absent from the micro-fossil record at Þingeyrar, it is possible to infer that fire was not used to clear the land of *B. nana* in this instance (Smith 1995). There remains the possibility that the deposition of the Hekla AD 1104 tephra had a negative impact upon *B. nana* (and other vegetation).

However, there is evidence available that would suggest that *B. nana* is relatively resilient to burial arising from the deposition of minerogenic material ≤10 cm thick (Vilmundardóttir et al. 2009). Allowing for compaction of strata over time, in Austur-Húnavatnssýsla, the Hekla AD 1104 tephra deposits are usually ≤2 cm thick (Larsen and Thorarinsson 1977).

Þingeyraklaustur: Plague (Þing IV, c. AD 1332–1515)

Iceland was beset by two outbreaks of 'plague', first in AD 1402, followed by another in AD 1495. There is an ongoing debate regarding the exact nature of these plague events (Karlsson 1996; Callow and Evans 2016), but there is no doubt about their impact in Iceland. It is estimated that the first outbreak killed at least half of the population of the island and both events are thought to have left at least some farms deserted (Karlsson 1996; Júlíusson 1997). With regard to Þingeyraklaustur, the plague was just as devastating; the Abbot and all of the monastery's brethren, bar one, died in the AD 1402 outbreak. The impact of this loss was sufficient enough to leave the institution devoid of a brotherhood for approximately 22 years (Kristjánsdóttir 2017). The later epidemic again took Þingeyraklaustur's Abbot, although he was swiftly replaced. This would suggest that at least some of the brethren survived this outbreak and it has been inferred that the second epidemic was not as virulent as that of AD 1402 (Karlsson 1996; Júlíusson 1997; Kristjánsdóttir 2017). With regard to the lay population at Þingeyraklaustur, nothing is known with regard to either epidemic. Within the wider landscape, it has been noted that around 36% of the farms tenured to Þingeyraklaustur had been abandoned by AD 1525, perhaps as a direct consequence of the two plagues (Karlsson 1996). On the continent, it is thought that instances of woodland recovery could be symptomatic of demographic change arising due to the Black Death (van Hoof et al. 2006; Yeloff and van Geel 2007). Given the timing of the resurgence of *B. nana* during the early LIA (Ogilvie and Jónsson 2001), and an absence of coprophilous fungi (i.e. livestock), similar demographic change affected by plague is the most plausible explanation for the recovery of *B. nana*, *Angelica* undiff., *Filipendula ulmaria*, SMC and OM, at Þingeyrar (Figures 4–6; 14 cm, c. AD 1401 ± 2 and 12 cm, c. AD 1492 ± 1). The earlier event seems to have initiated a relatively prolonged period (decades) of recovery while the second event (bearing in mind the limits of dataset) seems to have been comparatively short-lived. Perhaps the scale of recovery in each instance reflects the degree of impact of plague upon the human population? It has been suggested that woodland recovery in Iceland during the fifteenth century may embody a response to plague but not necessarily due to abandonment (Streeter, Dugmore, and Vésteinsson 2012); it may actually represent a change in land management regimes in response to declining population. There is some historical evidence to suggest that peasants resisted utilising outlying areas despite the demands of landowners (Júlíusson 1997). Similarly, not all abandonment may have been due to plague; climate cooling, volcanism and famine may all be implicated (Callow and Evans 2016). Nonetheless, the historical testimony for a period of desertion at Þingeyraklaustur due to plague in the fifteenth century is hard to ignore.

Due to an absence of other arable indicators (Erlendsson, Edwards, and Gísladóttir 2014; Riddell et al. 2018), and the coastal context, the single incidence of *Hordeum*-type pollen (Figure 4) is attributed to the presence of lyme grass (*Elymus arenarius*) at Þingeyrar; not cereal cultivation. Given the possible correlation between cereal cultivation and the establishment of the monastery at Viðey (Hallsdóttir 1993), the absence of evidence for cereal cultivation at Þingeyrar is perhaps a little surprising. The coastal location (mitigates frost) and presumably, high status of the monastery, intimate the potential for cereal cultivation despite the cooling climate regime (Riddell et al. 2018). As with charcoal and the intermittent signal for coprophilous fungi (already discussed with regard to Þing II), not to mention the poor dispersal ability of cereal pollen (Tweddle et al. 2005), the absence of pollen from cereal and arable weed taxa could be a consequence of the sample site being remote from the monastery/home farm.

Þingeyraklaustur: Erosion, the LIA and the Reformation (Þing V, c. AD 1515–1606)

The early sixteenth century witnesses a change in vegetation not seen at Þingeyrar since the foundation of the monastery c. 400 years earlier. Although a Cyperaceae dominated wetland prevails (Figure 7), *B. nana* gives way almost entirely to Poaceae (i.e. grassland), and to a somewhat lesser degree, an *Empetrum nigrum* wetland (Figures 4–6). The relatively strong representation of Caryophyllaceae (pinks) and *Silene vulgaris*-type (catchflies) could infer the presence of *Silene uniflora* (Sea campion), a species that favours a gravelly and sandy substrate (Kristinsson 1986; Ottósson, Sveinsdóttir, and Harðardóttir 2016). This implies either some degree of erosion or is associated with the re-deposition of coastal sands due to increasing storminess arising during the LIA (Ogilvie and Jónsson 2001). Soil degradation is a recognised feature of sixteenth century in Iceland, attributed to land management practices (grazing) originating during Landnám, persisting into the modern period, and exacerbated by deteriorating climate conditions (Dugmore et al. 2009; Gísladóttir et al. 2010). However, the sedimentary data for

Þingeyrar suggest stability for this period, with no additional influxes of minerogenic material (Figure 3). Notably, the coprophilous fungi reveal that livestock have returned to the landscape (Figures 4–6). An inventory for the monastery from AD 1525 suggests that a large body of livestock was present on the landholding, summarised as 56 cattle, 350 sheep and 11 horses (DI IX, p. 314). Whether or not this represents an increase on previous livestock numbers is unknown but this could explain the altered character of the vegetation and the possible inception of erosion. Meanwhile, the decline in *B. nana* may simply be revealing an increased demand for fuel for warmth in response to the LIA or ongoing scrub clearance for pasture (Figures 4–6). By AD 1552, Þingeyrarklaustur is receiving charcoal for fuel as a rental payment from its tenancy at Ásbjarnarnes (DI XII p. 451–454).

The sixteenth century also encompasses the Lutheran Reformation (AD 1551) whereupon Þingeyraklaustur fell into the hands of the Danish state. Ecological responses to the dynamic sixteenth century Protestant Reformation have been observed in Europe. For example, the pastoral hinterland of Furness Abbey evolved into one of mixed-arable farming due to the division of the monastic landholding between freeholders (Wimble, Wells, and Hodgkinson 2000). If a single sample can be trusted, a very slight increase in *B. nana* values at the expense of *Empetrum nigrum* wetland (Figure 4, 10.25 cm, c. AD 1561) could suggest some element of reduced human population, i.e. the dispersal of the brethren and lay community of Þingeyraklaustur, following AD 1551 (Ísleifsdóttir 2013). Otherwise, it appears that the general trajectory of vegetation change (from wetland to grassland) at Þingeyrar simply persists post-Reformation under the new administration of the Danish state.

Early Modern Þingeyrar (Þing VI, c. AD 1606–1766)

From the early seventeenth century, Þingeyrar remains in the hands of the Danish state within a colonial regime of trade monopoly and royal absolutism (Karlsson 2000). The landscape of Þingeyrar has become increasingly dominated by grassland (Poaceae) and associated apophytes (e.g. *Selaginella selaginoides*, *Rumex* spp. and *Diphasium*-type) at the expense of Cyperaceae dominated wetland (Figures 4–7). Coprophilous fungi (i.e. livestock) have become an almost permanent feature (Figures 4–6). Despite this, and the LIA, the sedimentary data suggest increasingly stable environmental conditions (Figure 3).

It is possible that such stability and the expansion of grassland habitats are a consequence of a considered land management policy introduced by the representatives of the Danish state in the face of a deteriorating climate. However, agricultural improvement is not thought to have arrived in Iceland until the latter part of the eighteenth century (Lucas 2012) and so far, has only been expressed archaeologically through stock breeding (Hambrecht 2009) and palaeoecologically via cereal pollen (Einarsson 1962) at the episcopal seat of Skálholt. The land register (AD 1702) known as Jarðabók (Magnússon and Vídalín 1926b) comments upon inundations of sand for Geirastaðir and abandoned Trumbsvalir (now within the landholding of Þingeyrar), both to the north of Þingeyrar. It therefore remains a possibility that the redeposition of minerogenic material by the wind is responsible for the drier ground conditions favoured by Poaceae at the sample site. Yet these inundation events do not appear in the sampled strata (Figure 3). Nor are there any further references in Jarðabók to inundations of sand at Þingeyrar or Neðri Vatnsdalshreppur (Lower Vatnsdalur) to the south (Magnússon and Vídalín 1926b). This would suggest that the documented events were localised, dictated by aspect with regard to wind direction and by proximity to the coast (perhaps arising in response to increasing storminess during the LIA). Þingeyrar is relatively remote from inland erosion areas and the active volcanic belt of Iceland which may further explain the relative stability in sedimentary conditions (Möckel, Erlendsson, and Gísladóttir 2017).

Jarðabók (Magnússon and Vídalín 1926b) remarks upon the limited availability of *hrísrif* (woody shrubs) at Þingeyrar. Again, *B. nana* data contradict this somewhat although it is possible that while it was available, it was not considered sufficient to be worth the effort of harvesting for fuel.

Conclusion

Interpreting palaeoecological data in hand with historical sources is common practice (e.g. Lomas-Clarke and Barber 2004; Tipping 2004) and at Þingeyrar there is a degree of parity between the two archives with regard to the establishment of the monastery. However, it is shown here that palaeoecological data are able to discern land use activities during the historical period that are invisible in documentary record, practices perhaps considered too base or humdrum by the medieval scribe to be worthy of mention. For example, the pollen record for Þingeyrar shows that from foundation the monastery was active in altering the character of its immediate environs, probably through livestock grazing, perhaps by deliberate scrub clearance by hand, but also through other forms of resource use, e.g. *B. nana* for fuel. Furthermore, this altered landscape can be seen to reflect monastic activity observed in the pollen record elsewhere in Europe, e.g. woodland clearance and conversion to pastoral landscapes. Conversely, recourse to the historical archive does allow the recovery of *B. nana* scrub during a period of climate cooling to be understood, i.e. the Icelandic plague events of the fifteenth century (and again in common with the effect plague had on vegetation on the continent). Where contradictions between the two sources of data arise, it is seen here as an interpretation opportunity where differences are seen to represent a more nuanced suite of circumstances, e.g. insights into the distribution of the influx of coastal sands during the LIA, or the availability of *hrísrif* for fuel as described in Jarðabók. It may even shed light on the documentary disparity over the foundation date of the monastery. It has not been possible to confidently attribute any specific changes in land use to the sixteenth century Protestant Reformation.

Overall, there is a gradual transition from *B. nana* dominated wetland to a pastoral landscape, initiated by settlers c. AD 877, consolidated by the monastery from the twelfth century, and intensified initially by the monastery and then by the Danish state from the sixteenth century. Although the proportions between the different habitat types have changed, ecological equilibrium was sustained throughout (Hallsdóttir 1987), i.e. there is little evidence for erosion on a large scale and vegetation cover is maintained. The inferred transition appears to be led by human activity, perhaps enhanced by a deterioration in climate conditions, especially from c. AD 1500. Documented influxes of coastal sands during the eighteenth century appear to be localised.

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