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Land cover and exploitation of upland resources on the Høg-Jæren Plateau, southwestern Norway, over the last 6500 years

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ABSTRACT

This study explores the use of upland resources on the Høg-Jæren Plateau (360 m asl) in southwestern Norway during the last 6500 years. Human activities and land-use variations were reconstructed using a compilation of data from pollen analysis of six sediment cores retrieved along an altitudinal transect belonging to the present day farm Aniksdal (approx. 31 km^2), with archaeological finds and historical records. Vegetation modelling was also used to quantify land-cover at regional (REVEALS model) and local (LOVE model) scales. The combined records show that humans were active in the area during the last 6500 years, and they created increasingly more open land in the region (from 60 to 90% cover). Locally, the land-use in the uplands varied substantially, but with generally increased cover of heath- and/or grassland through time, accompanied by greater burning as indicated by the rise in microscopic charcoal. These vegetation changes suggest active clearance and probable management using fire throughout the period studied. Hunter-gatherers dominated the land-use in the early part of the record (*c*. 4500–2400 BCE). They possibly kept livestock sometime after 3950 BCE, though management favouring wild animals and certain plants is also a reasonable explanation for the increased open land during this period. After 2400 BCE, an agricultural society was established and grazing activities dominated the land-use at Høg-Jæren (*c*. 2400–500 BCE), followed by establishment of the infield/outfield system (*c*. 500 BCE–1000 CE), with permanent fields and settlements in the valley, and a mixed use of the uplands. Hay-production became increasingly important, and shielings were established in the uplands during the last 1000 years, probably used as bases for a combination of grazing, hay-production and dairy farming. The study shows the importance of combining data from several disciplines to provide a relatively detailed spatial and temporal reconstruction of human activity.

1. Introduction

Marginal land has been an integrated part of the agrarian system in many parts of Europe, in both prehistoric, as well as historic times (Andersson et al., 1998; Brown et al., 2012; Collis et al., 2016; Davies, 2007; Emanuelsson, 2009). In southwestern Norway, this agrarian system is customarily portrayed as relatively homogeneous in relation to the surrounding landscape, but the bedrock and the soil map reveal significant variations, which provide a mosaic of resources useful for past societies (Lillehammer, 2004; Lillehammer and Prøsch-Danielsen, 2001; Myhre, 1974; Prøsch-Danielsen and Fyllingsnes, 2013; Prøsch-Danielsen and Simonsen, 2000a, 2000b; Prøsch-Danielsen et al., 2018; Rønneseth, 1974, 2001).

Exploitation of uplands, often crucial to many past societies, provided a variety of resources. For example, hunter-gatherer groups may have used the uplands for hunting and fishing (Bang-Andersen, 1973), while for agrarian-based societies, pasturing, mowing and dairy farming were likely common activities (Kvamme, 1988; Prøsch-Danielsen, 1990; Stene, 2015). During the 19th century (and likely earlier), the uplands were exploited during the summer by using shielings (summer farms), i.e. one or several buildings as a base for pasturing, dairying and hay production, of which the latter dominated this practice in southwestern Norway (Reinton, 1969) (Fig. 1).

The Høg-Jæren Plateau in southwestern Norway is a type of upland situated at an intermediate altitude (80 to 360 m asl.) in the inner part of the coastal heathland (Steinnes, 1988; Kaland and Kvamme, 2013) (Fig. 1A and B). The area contains a variety of archaeological remains, such as shielings, haystack foundations, clearance cairns and animal pens, which indicate complex land-use patterns through time (Prøsch-Danielsen and Fyllingsnes, 2013). Its proximity to the coastal plain also

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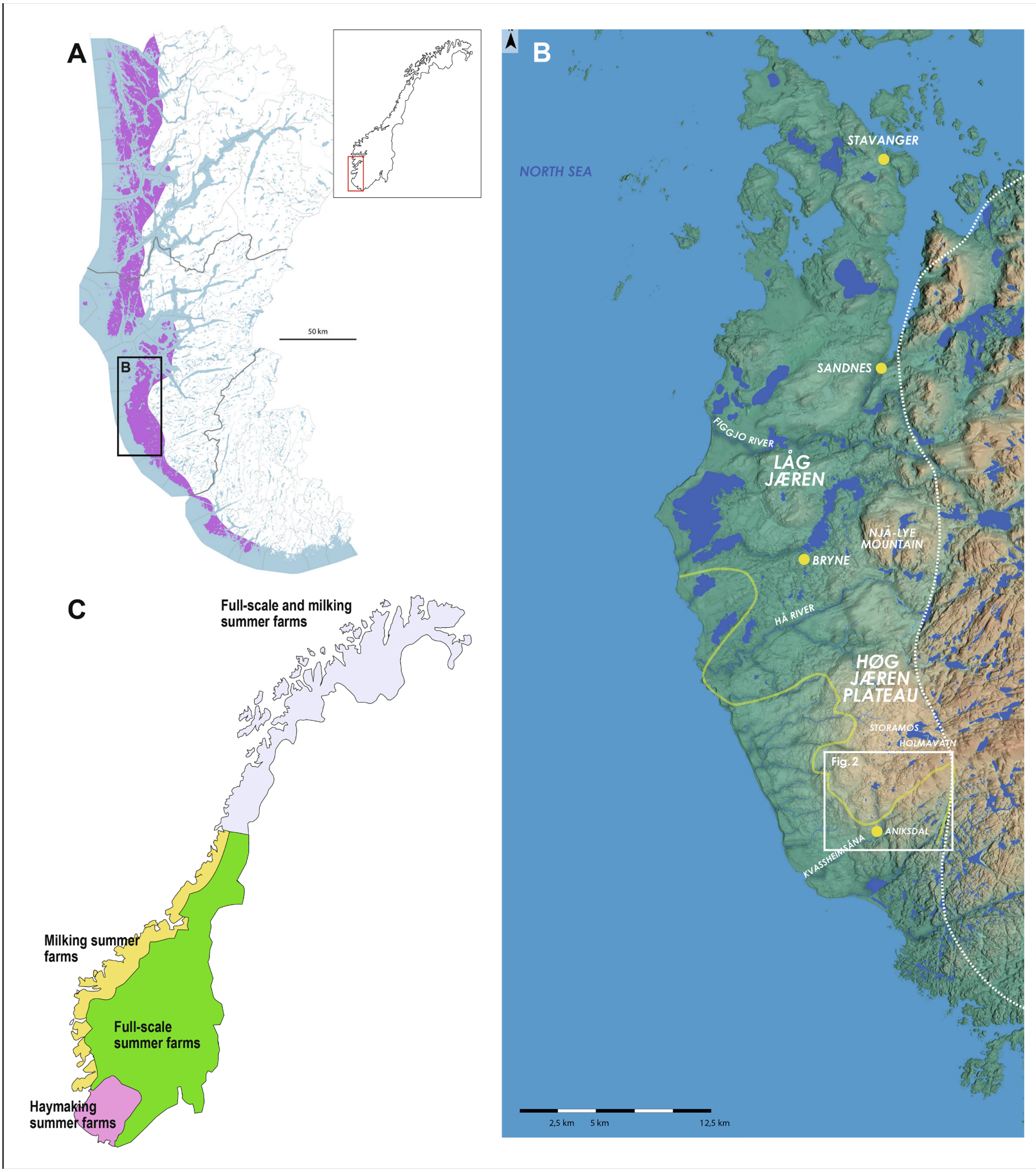

Fig. 1. A). Map showing the distribution of coastal heathland (pink) in southwest Norway (map by Hjelle, K. and Prøsch-Danielsen, L.). Inset: map of Norway. B). The low-lying coastal area (Låg-Jæren) and upland Høg-Jæren Plateau in southwestern Norway. The yellow line marks the border of one of the marginal moraines in the area, formed by the ice sheet at c. 16 500 BCE. The white line marks the present eastern border of the coastal heathland section (Moen 1999). The study area (Fig. 2) is inserted (map data: Kartverket, graphics: T. G. Bell). C). The distribution of summer farm/shieling practices in Norway, showing that the study area is part of a region where hay production was the incentive for the maintenance of summer farms in the 19th century (and likely earlier) (Reinton, 1969). In areas with full-scale summer farms, the dairy products were processed on site, whereas at milking summer farms the milking was part of the daily work, but only partly processed on site.

suggests different resource exploitation compared to more traditional subalpine-alpine uplands in Norway (Bjørgo, 1986; Kvamme, 1988; Magnus, 1986; Prescott, 1995; Prescott and Melheim 2017; Prøsch-Danielsen, 1990; Randers and Kvamme, 1992).

The present study explores past human upland activities on the Høg-Jæren Plateau through 6500 years. The aim is to provide a relatively detailed temporal and spatial record of past land-use variations, with a focus on the exploitation of upland resources, in particular shieling practices linked to grazing and mowing. The study area comprises the present day farm at Aniksdal, which allows its history to be investigated by using a

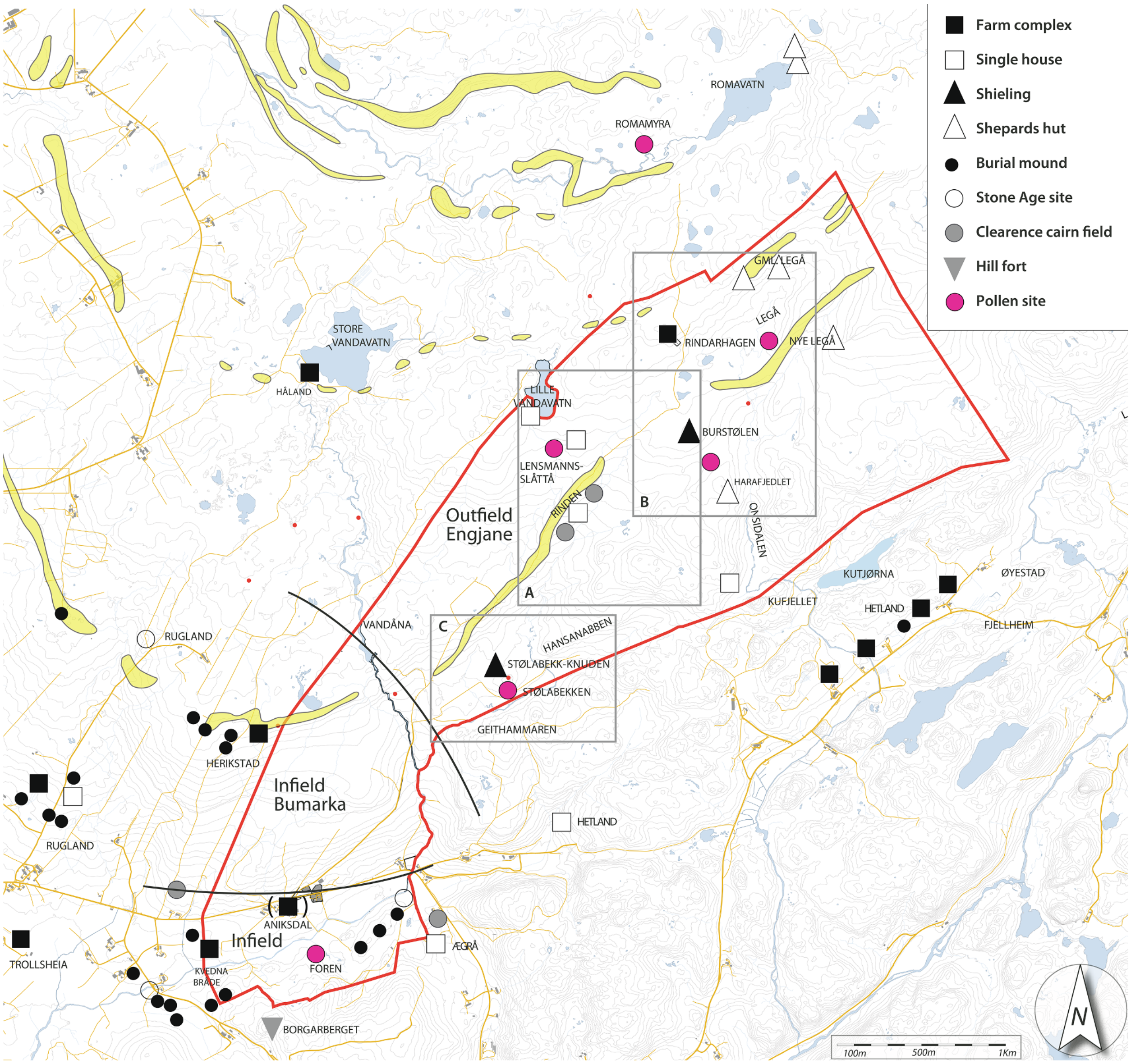

Fig. 2. Map showing the land belonging to the present day farm Aniksdal (red line marks the border), with infield close to the settlement and upland/outfield areas to the northeast. The location of place names, archaeological remains and pollen sites mentioned in the text are also shown. The yellow lines mark marginal moraines, of which one (Rinden) runs through the upper part of the study area. The location of a possible farm at Aniksdal (that predated the present one) is inferred from archaeological stray finds. Boxes A–C correspond to Fig. 5A–C.

combination of archaeological, historical and palaeoecological records. The main component is pollen analysis of sediment cores obtained along an altitudinal transect through the study area. In addition, vegetation modelling was applied (i.e. Landscape Reconstruction Algorithm), which compensates for inherent biases related to the pollen representation of vegetation, in order to quantify the land cover at regional (submodel REVEALS) and local (submodel LOVE) scales (Sugita 2007a, b).

2. The study area

The present-day farm Aniksdal covers 31 km^2 and stretches 7 km from the low-lying coastal plain to the upland plateau of Høg-Jæren (Figs. 1 and 2). The area is characterized by mild winters, relatively long growing seasons (mean annual temperature ≥ 4 °C) and high levels of precipitation (1400–1800 mm per year) (Moen, 1999). The landscape is heterogeneous with bedrock exposed in the southeastern part, and with a cover of Quaternary deposits in the northwestern part (Jorde et al., 1995). The Høg-Jæren Plateau is characterized by a series of marginal moraines, one of which, called "Rinden", runs through the central part of the farm and influences human activities and local movements (Knudsen et al., 2006; Raunholm et al., 2003; Sejrup et al., 1998; Stalsberg et al., 1999).

In the traditional agriculture at Aniksdal (*c*. 1800–1950 CE), the infield area was separated in two parts; an area called *Foren* used for cultivated fields and hay-meadows, and an area called *Bumarka* (fertilized) used for grazing and hay-meadows. *Engjane* (not fertilized) was the name applied to hay-meadows in the outfields (Fig. 2). The outfields were common land, ostensibly shared between neighbours, but often subject to exclusive usage rights. This common land was legally transferred into private ownership by state reforms from 1800 CE. Although, heathland was maintained by burning until the 1950s, mowing and peat cutting ceased in the uplands after the Second World War, while herding stopped around 1910 (Prøsch-Danielsen and Fyllingsnes, 2013).

Presently, the traditional infield area and part of the outfield area are used for grass cultivation. The outfields comprise a mosaic of grass-and heathland used primarily for grazing. The heathland is dominated by *Calluna vulgaris*, followed by *Erica tetralix*, and though poor in diversity, it also contains a few sub-oceanic species, such as *Sanguisorba officinalis* and *Arnica montana*, the latter being an indicator species for hay-meadows (Steinnes 1988:19, 61; DN, 2009:13).

Heathland is currently an endangered ecosystem in southwestern Norway, and most of the study area is within the 13 km^2 protected landscape zone called "Synesvarden". Established in 1993, plants and their environments are protected and maintained in this zone, as well as the adjacent landscapes.

3. Material

3.1. Archaeological and historical data-set

Field surveys, previous excavations and radiocarbon dates from the study area were compiled for this study (Bang-Andersen, 1973, 1979, 1988, 2005; Lillehammer, 1974, 1975, 1977, 1988; Lillehammer and Andreasen, 1973/74; Wankel, 2010). These data were supplemented by artefacts held in museum collections, archives (digitally accessible in the www.unimus.no database), ethno-historical literature and interviews with present and previous farmers (Prøsch-Danielsen and Fyllingsnes, 2013). The archaeological field surveys were not carried out systematically, and finds are therefore skewed towards readily identifiable categories (Fig. 2). The archaeological chronology follows Scandinavian conventions (Table 1).

Mesolithic to Middle Neolithic (6500–2400/2350 BCE): About 50 hunting sites have been identified in Høg-Jæren and they are concentrated around the shores of the lakes, Storamos and Holmavatn, approx. 2 km north of the study area (Fig. 1B). Based on typology, the sites collectively span the periods from the Late Mesolithic through to the Middle Neolithic A, i.e. from c. 4600 to 2750 BCE, and the assemblages and locations indicate that the sites can be associated with hunting and fishing, probably on a seasonal basis (Fig. 3). One of these sites has been excavated and radiocarbon dated to 4040–3644 cal. BCE (Bang-Andersen, 1973, 1979), i.e. around the transition between the Mesolithic and the Neolithic.

Late Neolithic (2400/2350–1750 BCE): At Høg-Jæren Plateau, there are numerous stray finds of daggers, sickles and points of Late Neolithic age (www.unimus.no). A site at Rugland (approx. 2 km north of the farm at Aniksdal) was excavated in the late 1970 s (Lindblom, 1982). The excavation recovered flints associated with bifacial techniques, some sherds of pottery, part of a saddle quern, a fragmentary fishhook made out of bone (probably sheep/goat), bone fragments possibly of cod and sheep/goat, and 15 kernels of naked barley (*Hordeum vulgare* var. *nudum*). A radiocarbon date from the hearth (2126–1693 cal. BCE), combined with evidence from the pottery, the bifacial points and the debitage suggest the site can be dated to the Late Neolithic. Tentative interpretations inferred that the site was seasonally exploited (Lindblom, 1982; Simonsen et al., 1982), but its location also suggests it could have supported a farm with small-scale cereal cultivation and livestock rearing, as well as sustaining fishing and hunting.

Table 1
Archaeological periods used in this study, following Scandinavian conventions.

Period	From calibrated year BCE/CE	To calibrated year BCE/CE
Late Mesolithic	6500 BCE	3950 BCE
Early Neolithic Period	3950 BCE	3300 BCE
Middle Neolithic Period A	3300 BCE	2750 BCE
Middle Neolithic Period B	2750 BCE	2400/2350 BCE
Late Neolithic Period	2400/2350 BCE	1750 BCE
Early Bronze Age Period I-III	1750 BCE	1100 BCE
Late Bronze Age Period IV-VI	1100 BCE	500 BCE
Pre-Roman Iron Age	500 BCE	1 BCE
Roman Iron Age	1 CE	400 CE
Migration Period	400 CE	600 CE
Merovingian Period	600 CE	800 CE
Viking Age	800 CE	1050 CE
Medieval Period	1050 CE	1500 CE
Post Medieval Period	1500 CE	present

Iron Age (500 BCE – 800 CE): Four farm complexes have been identified in the southern part of the valley where the modern farm Aniksdal is located, while four farms have been identified near Lake Kutjønna, south of Onsdalen (www.unimus.no). The oldest of these sites is Kvednabråde (*c.* 200–100 BCE to c. 300 CE) situated within the infield at Aniksdal (Lillehammer, 1974, 1975; Lillehammer and Andreasen, 1973/74). Visible plough marks underneath the settlement deposits provide evidence of agricultural activity predating the settlement. Migration Period (400–600 CE) burial mounds and artefacts (Fig. 4A and B) indirectly infer later Iron Age settlements (Archaeological Museum in Stavanger, Topographical archive; Helliesen, 1898; Kristoffersen, 2000; Lillehammer, 1977).

At the marginal moraine of Rinden, a building with two rooms, and an uneven and rocky floor, was investigated (Lillehammer, 1988; Wankel, 2010) (Fig. 5A). The lack of finds and cultural deposits suggested that the building served as storage, possibly for drying fodder. Two charcoal fragments below the remains of the building were dated to 1260–1050 BCE and 1495–1270 BCE, which probably represent earlier clearance of the area. Close to this building, there are several clearance cairns, four animal pens, a group of haystack foundations (four-post structures) and an enclosure made of peat and stones, which are probably from multiple periods. One of the clearance cairns was dated to *c.* 100 CE, thus indicating the oldest phase of the building (Lillehammer, 1988; Wankel, 2010).

Viking Age and the Medieval Period (800–1500 CE): A single bladed sword from *c.* 800–900 CE was found close to the present day farm at Aniksdal (Petersen, 1919). At Rindarhagen (Figs. 2 and 5B), the remains of two houses were identified within an enclosed area that covers 10,700 m^2, but were destroyed in 1960. However, clearance cairns, a linear stone clearance structure, a passage way for livestock and an animal pen are still intact, and these structures probably belonged to the same farm. A trial trench was dug through the animal pen (outside the farm's fenced-in area), and which dated to 1075–1170 CE and 1305–1370 CE (Prøsch-Danielsen and Fyllingsnes, 2013). A similar set of structures were also located at the farm of Håland near Lake Store Vandavatn, about 3 km north of Aniksdal. These were dated to the Medieval Period (1050–1500 CE; Archaeological Museum in Stavanger, Topographical archive). These two farms were probably established during the Medieval Period as populations grew, and later abandoned after the Black Death pandemic (1350 CE) (Fyllingsnes, 2013). A house foundation at Burstølen, situated approx. 600 m south of Rindarhagen, dated to 1190–1295 CE, may have served as a shieling belonging to the Medieval settlement at Rindarhagen.

Several small rectangular single-house remains have also been found in the wider Høg-Jæren area. One of these is situated at the edge of Lake Lille Vandavatn (dated to the Medieval Period, *c.* 1305–1400 CE), and one is situated near Kufjellet (not dated). The purpose of these small houses is not certain, but they were possibly used as shelters for shepherds and their livestock.

Post Medieval Period (1500 CE–present): Remains of five single small houses (3.5 × 4 m), two animal pens, an enclosure built of peat and a group of haystacks are situated on the south facing slopes at Stølabekk-knuden (Figs. 2 and 5C). A still visible cattle track connects the present day farm at Aniksdal with the structures at Stølabekk-knuden, which suggests they were linked and in use at the same time. The charcoal layer in one of the houses was dated to 1630–1950 CE, and the use of these buildings is not in the memory of recent farmers, which suggests that the structures at Stølabekk-knuden were in use in the 1600s or 1700s.

A series of small rock shelters and shepherds' huts, situated 3–5 km from the Aniksdal farm, probably sheltered shepherds and livestock.

Fig. 3. Selected archaeological artefacts from the study area. From left to right: conical microblade core of flint (Late Mesolithic), tanged blade point of flint (Early/Middle Neolithic), tanged blade point of quartz (Early/Middle Neolithic), blade struck from a cylindrical core (Early/Middle Neolithic), tanged point of rhyolite (Early/Middle Neolithic) and bifacial point of flint (Late Neolithic/Early Bronze Age). Rhyolite stems from a quarry at Siggjo on the coastal island of Bømlo, approx. 130 km north of the study area (Alsaker 1987). Photo: Annette Øverlid/UiS-AM.

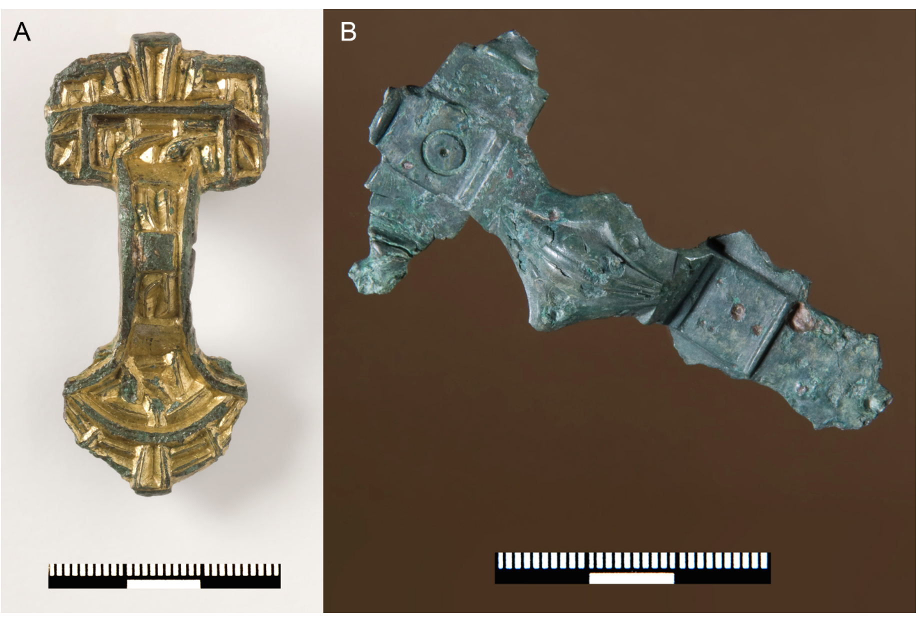

Fig. 4. A). Small gilded relief brooch from Olsheiå at Aniksdal, decorated with animal art (c. 500–550 CE). B). Cruciform brooch found in a grave at Kvednabråde (c. 400–550 CE). Photo: Terje Tveit/UiS-AM.

According to local farmers, some of them were in use up to 1910. Two of these near Legå, were dated to 1660–1960 CE and 1690–1960 CE, respectively. In addition, a series of twenty haystack foundations are found in *Engjane* on both sides of the marginal moraine of Rinden, stretching from Legå down to *Bumarka* (Fig. 2).

3.2. Palaeoecological material

Five sediment cores were retrieved from fens belonging to the farm at Aniksdal: one from the current infield at *Foren*, and four from the outfield *Engjane* (Fig. 2). In addition, one sediment core was retrieved from the present outfield (Romamyra), belonging to the neighbouring farm Ualand to the north. The fens range in size from 1.5 to 15.5 ha.

Foren (62 m asl, 3.3 ha) lies 400 m southeast of the modern farmyard at Aniksdal near the stream Kvasseimsåna. The site was a fen until 2008, dominated by grass and sedge cover, but is today used for grass cultivation.

Stølabekken (156 m asl, 4.2 ha) is situated near a small stream and was originally part of a large wetland. Presently, it is used for grass cultivation. The site is situated near areas known to have been mown in the 1800–1900s.

Lensmannsslåttå (235 m asl, 15.5 ha) has previously been described and published as the site Aniksdalsheia (Prøsch-Danielsen and Simonsen, 2000a). Stands of *Molinia* grasses and dwarf shrubs such as *Calluna vulgaris* dominate the plant cover. The site is part of a sloping fen that extends 2 km to the south from Rindarhagen. During recent centuries, the fen was mown and used for peat cutting, as shown by a series of four-posted haystacks, a barn from *c*. 1900 CE and foundations for storing peat.

Burstølen (237 m asl, 1.5 ha) is a fen with a plant cover dominated by *Calluna vulgaris*. The fen has been used for peat cutting, and remains of a building for storing peat are present 100 m to the south of the fen.

Legå (245 m asl, 4.8 ha) is a large fen with a high minerogenic content, and a mixed plant cover of both nutrient-poor and nutrient-rich plants. Some species, such as *Leontodon autumnalis* and *Poa pratensis*, indicate intense grazing (Det norske jord- og myrselskap, 1982;

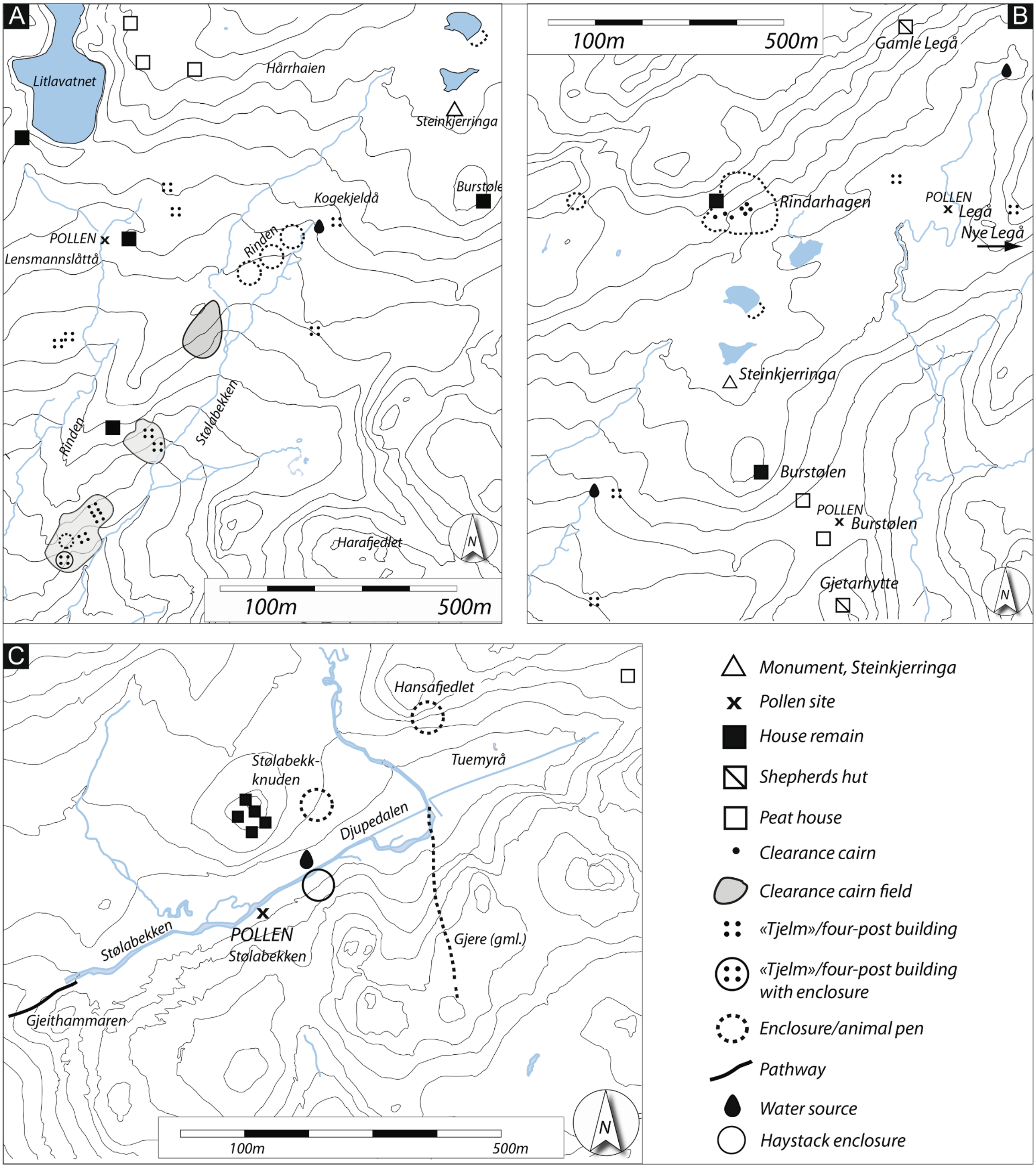

Fig. 5. A). Close up of the area with a building (probably a barn or milking shed) at Rinden. B). Close up of the farm complex Rindarhagen and the shieling Burstølen and their surroundings. C). Close up of the area at the shieling Stølabekk-knuden. Figures modified from Prøsch-Danielsen and Fyllingsnes (2013).

Steinnes, 1988:60–63).

Romamyra (265 m asl, 6.2 ha) was described by Steinnes (1988:60–63) as being a flat fen with nutrient-poor species, as well as species favouring intermediary nutrient conditions. Some parts were described as ombrotrophic, dominated by either *Calluna* or *Erica tetralix*. A preliminary pollen percentage diagram from Romamyra was previously published (Prøsch-Danielsen and Simonsen, 2000a).

4. Methods

4.1. Pollen and charcoal analyses

Sediment cores were recovered using a Russian corer at two sites, Foren and Legå. At the other sites, PVC-tubes were driven into the peat. When using PVC-tubes, the youngest sediments are usually compressed and the age-depth relationship can be difficult to resolve in the upper part of such cores. To access uncompressed material, additional monoliths were recovered from the uppermost metre of peat at the Burstølen and Lensmannsslåttå sites.

Sub-samples for pollen, spore and microscopic charcoal analyses were taken at 2.5–10 cm intervals, prepared using standard methods (Fægri and Iversen, 1989) and their content was identified using the key in Fægri and Iversen (1989), and the reference collection at the University of Stavanger. Cereal pollen types were separated by studying the structure of the pollen wall (Beug, 2004). Microscopic charcoal particles (10–200 µm) were counted for all sites during the pollen analysis,

Table 2
Radiocarbon dates obtained from archaeological remains, charcoal layers and cultivated fields in study area (the farm Aniksdal, Hå municipality, southwestern Norway).

Locality	m asl	Google earth	Context	Dated material	Lab. id.	Conv. radiocarbon age (BP)	BCE/CE (2 sigma)	Sampling year
Aniksdal, farm	80	58,3418 N, 5,4445 E	Field, agricultural phase	Hordeum vulgare var vulgare	B-293859	1770 ± 30	138–345 CE	1973/74
Hansanabben	170	58,3512 N, 5,4627 E	Charcoal layer in soil, clearing of forest	Charcoal, Betula	TUa-7661	2780 ± 35	1008–838 BCE	2008
Stølabekk-knuden, shieling	180	58,3564 N, 5,4614 E	Charcoal layer, building 2, latest use	Charcoal, Betula	TUa-7663	225 ± 30	1640–1931 CE	2008
Rinden, clearings cairn	198	58,3529 N, 5,4622 E	Layer 3, infill min. age of clearings cairn	Charcoal, Betula	TUa-7656	1910 ± 35	18–214 CE	2008
Rinden, clearings cairn	198	58,3529 N, 5,4622 E	Layer 5, just below clearings cairn, max. age	Charcoal, deciduous trees	TUa-7657	2860 ± 35	1127–919 BCE	2008
Rinden, below building remains	220	58,3536 N, 5,4631 E	Below building remains, clearing of forest	Charcoal, Betula	TRa-429	2950 ± 30	1260–1051 BCE	2009
Rinden, below building remains	220	58,3536 N, 5,4631 E	Profile B, stone 4, below building remains, clearing of forest	Charcoal, Betula	TRa-1654	3115 ± 40	1494–1269 BCE	2010
Lille Vandavatn, building remains	250	58,3557 N, 5,4617 E	Fire place/cultural layer, latest use	Charcoal, Betula + short lived	TUa-7662	615 ± 30	1295–1401 CE	2008
Burstølen, shieling	252	58,3554 N, 5,4715 E	Fire place, latest use	Charcoal, unspec.	TUa-7660	780 ± 35	1190–1283 CE	2008
Rindarhagen, enclosure	257	58,3646 N, 5,4715 E	Just below enclosure, max. age	Charred seeds	TRa-425	645 ± 25	1283–1394 CE	2009
Rindarhagen, enclosure	257	58,3646 N, 5,4715 E	Just below enclosure, max. age	Peat	TRa-428	920 ± 25	1030–1167 CE	2009
Nye Legå, shepherd's hut	265	58,3680 N, 5,4744 E	Fire place, latest use	Charcoal fragments, Ericaceae	TUa-7659	70 ± 30	1691–1924 CE	2008
Gamle Legå, shepherd's hut	280	58,3624 N, 5,4732 E	Fire place, latest use	Charcoal fragments, Ericaceae	TUa-7658	160 ± 35	1664–1912 CE	2008

and presented as the percentage of the sum of pollen and number of charcoal particles. The TILIA computer program (v. 2.0) was used to create pollen percentage diagrams and to identify local vegetation zones by stratigraphically constrained cluster analysis (Grimm, 1987, 1992).

4.2. Radiocarbon dating

Four to six bulk sediment samples of peat were taken from each sediment sequence and radiocarbon dated using accelerator mass spectrometry (AMS). Based on these dates, the OxCal program (v. 4.3) was used to create age-depth models for each sediment core using the P_Sequence deposition model, which takes the distance between dated samples into account (Bronk Ramsey, 2008, 2009). The k-value parameter (the number of accumulation events per unit depth) was chosen as high as possible, but with an agreement index above 60% for each age-depth model (Bronk Ramsey, 2008).

When possible, remains of buildings, clearance cairns, enclosures and cultivated fields were dated using charcoal from short-lived trees and shrubs, as well as charred cereal kernels. ^{14}C values were calibrated based on the IntCal13 calibration curve (Bronk Ramsey, 2009; Reimer et al., 2013). The midpoint for the calibrated years BCE/CE (2σ rounded to nearest 100 year) are used in the text below.

4.3. Vegetation modelling

To quantify the regional and local vegetation, the landscape reconstruction algorithm (LRA) was applied, which is a two-step approach (Sugita, 2007a,b). First the REVEALS model (v. 4.2.2) was used to estimate the regional vegetation cover (10^4–10^5 km^2), based on the six pollen records obtained from the study area. In addition, for the purpose of estimating the background loading of pollen (as input in the LOVE model), the "leave-one-out" approach was employed, i.e. the target site used for local vegetation estimates was excluded from the sites used for regional vegetation estimates. Hence, the REVEALS model was run an additional six times; each run with a different combination of sites. Optimally, the REVEALS model should be based on pollen extracted from large lakes or bogs (> 100 ha), but pollen counts from multiple small sites may also be used (Sugita, 2007a; Sugita et al., 2010; Trondman et al., 2016).

Subsequently, the LOVE model (v. 3.2.0) was run six times (each time with different input for regional vegetation estimates), based on pollen counts from small sites (< 50 ha) to estimate the local vegetation within the relevant source area of pollen (RSAP) (Sugita, 2007b). Because pollen records from only one site were used in each LOVE model run, it was difficult to reliably estimate the RSAP based on the LOVE model (Sugita, 2007b; Sugita et al., 2010). A previous modelling approach, based on modern vegetation from western Norway, suggests a RSAP of 900–1100 m (Hjelle and Sugita, 2012), which is the assumed radius (RSAP) around each site also used in this study.

500-year time windows were selected. Obviously, there are inherent drawbacks to time spans of this size, delimited by mechanically drawn borders. We were compelled to do so because of chronological uncertainties and the available pollen data (Appendix A). The pollen counts were pooled when more than one pollen sample occurred within a time window.

17 common taxa were selected for regional and local land-cover reconstructions. As estimates of relative pollen productivity (RPPs) for several taxa have not been obtained from western Norway, a combination of RPPs were used from western Norway, Denmark and the LANDCLIM project (Appendix B) (Hjelle and Sugita, 2012; Mazier et al., 2012; Nielsen, 2004). A similar combination of RPPs has been used and performed well in previous studies in western Norway (Hjelle 2015; Hjelle et al., 2015b; Mehl and Hjelle, 2016; Mehl et al., 2015). In the model runs, Prenticés model of pollen dispersal and deposition for bogs was used (Prentice, 1985, 1988) and the maximum spatial extent of the

Table 3
Radiocarbon dates obtained from sediment cores used in this study. Five sediment cores were from the land belonging to the present day farm Aniksdal and one core (Romamyra) was from the neighbouring farm Ualand, Hå municipality, southwestern Norway. The dated material was peat for all samples.

Locality	Depth below surface	Lab. id.	Conv. radiocarbon age (BP)	BCE/CE (2 sigma)	Sampling year
Foren	7.5–8.5 cm	B-363988	370 ± 30	1447–1634 CE	2008
Foren	14–15 cm	B-363989	690 ± 30	1265–1388 CE	2008
Foren	29–30 cm	B-363990	1080 ± 30	894–1018 CE	2008
Foren	47.5–48.5 cm	B-363991	3050 ± 30	1401–1226 BCE	2008
Foren	60–61 cm	B-363992	4380 ± 30	3090–2913 BCE	2008
Foren	104–105 cm	B-381063	7200 ± 30	6203–6003 BCE	2008
Stølabekken	19–20 cm	B-381059	1030 ± 30	901–1116 CE	2008
Stølabekken	29–30 cm	B-381060	1840 ± 30	86–242 CE	2008
Stølabekken	64–65 cm	B-381061	3570 ± 30	2022–1781 BCE	2008
Stølabekken	99–100 cm	B-381062	4200 ± 30	2894–2678 BCE	2008
Lensmannsslåttå	10–11 cm	B-363987	100 ± 30	1682–1935 CE	1997
Lensmannsslåttå	80–82.5 cm	T-13496	2470 ± 50	769–416 BCE	1997
Lensmannsslåttå	109–110 cm	TRa-2585	3990 ± 35	2619–2410 BCE	1997
Lensmannsslåttå	132–133 cm	TRa-2586	4905 ± 40	3768–3639 BCE	1997
Lensmannsslåttå, B-core	33.5–34.5 cm, est depth core A, 37–38 cm	B-292363	780 ± 30	1210–1281 CE	1997
Lensmannsslåttå, B-core	52.5–53.5 cm, est depth core A 66.5–67.5 cm	B-292364	1980 ± 30	45 BCE–77 CE	1997
Burstølen I	18–19 cm	TRa-2587	2425 ± 35	751–403 BCE	2008
Burstølen I	56–57 cm	TRa-2588	3555 ± 40	2020–1768 BCE	2008
Burstølen I	70–71 cm	B-381522	4490 ± 30	3348–3090 BCE	2008
Burstølen I	78–79 cm	TRa-2589	4585 ± 40	3502–3105 BCE	2008
Burstølen II	19.5–20.5 cm	B-425145	1790 ± 30	133–330 CE	2008
Burstølen II	24.5–25.5 cm	B-381523	2170 ± 30	360–116 BCE	2008
Burstølen II	29.5–30.5 cm	B-425146	2620 ± 30	831–775 BCE	2008
Burstølen II	45–46 cm	B-425147	3250 ± 30	1613–1451 BCE	2008
Burstølen II	47.5–48.5 cm	B-381521	3740 ± 30	2275–2035 BCE	2008
Legå	26–27 cm	B-315530	250 ± 30	1521–1801 CE	2011
Legå	53–54 cm	B-315531	1100 ± 30	887–1013 CE	2011
Legå	67.5–68.5 cm	B-381524	2160 ± 30	358–108 BCE	2011
Legå	124–125 cm	B-315532	3080 ± 30	1418–1264 BCE	2011
Legå	199.5–200.5 cm	B-381525	4300 ± 30	3011–2880 BCE	2011
Romamyra	15–16 cm	B-425141	1260 ± 30	689–882 CE	1996
Romamyra	35–36 cm	B-425142	2840 ± 30	1108–917 BCE	1996
Romamyra	74–76 cm	T-13085	5140 ± 85	4228–3712 BCE	1996
Romamyra	92–93 cm	B-425143	5800 ± 30	4721–4554 BCE	1996

regional vegetation was set to 50 km.

5. Results

5.1. Radiocarbon dates and chronologies

The dates from the archaeological contexts ranged between *c.* 1900 BCE and 1800 CE (i.e. Late Neolithic to Post-Medieval periods), which provide age estimates of human activity and archaeological structures in the study area (Table 2). Dates obtained from the sediment cores were used to infer ages for vegetation change at selected levels in the pollen diagrams (Table 3). The dates from the sediment cores were also used to: create age-depth models for each site; estimate an age (2σ midpoint) for each pollen sample and; divide samples into time windows (4500 BCE–2000 CE) for the REVEALS and LOVE modelling (Appendix C).

5.2. Pollen percentage diagrams

Two pollen percentage diagrams are presented here to provide greater chronological detail of the vegetation changes and some additional taxa than can be obtained from the vegetation modelling. The pollen percentage diagrams from Foren (currently an infield) and from Legå (currently an outfield) provide examples of vegetation development in two separate areas of land belonging to the present day farm Aniksdal (Fig. 2). Pollen percentage diagrams for the remaining four sites can be viewed online (Appendix D-G).

Foren. Six local vegetation zones were identified (F1a–2d) covering the last c. 8000 years (Fig. 6).

F1a (*c.* 6000–3000 BCE): The pollen composition was dominated by woodland taxa, such as *Betula, Alnus, Corylus* and *Quercus*, and ferns (Polypodiaceae). A few herbs were also present throughout this time interval, such as *Potentilla*-type, *Melampyrum, Filipendula, Artemisia* and Poaceae.

F1b (*c.* 3000–1300 BCE): Open land taxa became gradually more common, in particular Poaceae, Cyperaceae, *Potentilla*-type, *Succisa* and *Plantago lanceolata*. Increasing numbers of coprophilous fungal spores in the Sordariaceae were also identified.

F2a (*c.* 1300 BCE–1000 CE): Woodland taxa continued to decline, while *Myrica*, *Calluna vulgaris* and microscopic charcoal (to approx. 30%) distinctly increased. Grassland taxa, such as *Plantago lanceolata* and *Rumex acetosa*-type were continuously present from this time. A few cereal (*Triticum* and *Hordeum)* pollen were recorded during this time interval.

F2b (*c.* 1000–1300 CE): Open land taxa were at a maximum. *Plantago lanceolata*, *Rumex acetosa,* Cyperaceae, Poaceae and Sordariaceae, showed relatively high values in this time interval. A few cereal pollen grains were recorded, while microscopic charcoal levels reached a maximum of approx. 50% at *c.* 1000 CE.

F2c (*c.* 1300–1500 CE): Microscopic charcoal and open land taxa abundances decreased, while the shrub *Myrica* increased.

F2d (*c.* 1500 CE–present): Cereal pollen reached their highest values, with a mixture of *Triticum, Triticum/Avena*-type*, Hordeum* and *Secale.* The grassland herb *Rumex acetosa* was relatively common, while other open land taxa, such as *Plantago lanceolata*, *Spergula arvensis* and Chenopodiaceae were present.

Legå. The pollen diagram from Legå covers the last *c.* 6000 years. Six local vegetation zones were identified (L1–L4b) (Fig. 7).

L1 (*c.* 4000–2200 BCE): The pollen composition was dominated by herbs, such as *Filipendula*, *Rumex acetosa*-type, *Ranunculus acris*-type and *Valeriana*. The shrubs *Juniperus* and *Salix* were also relatively common, while microscopic charcoal values were relatively high

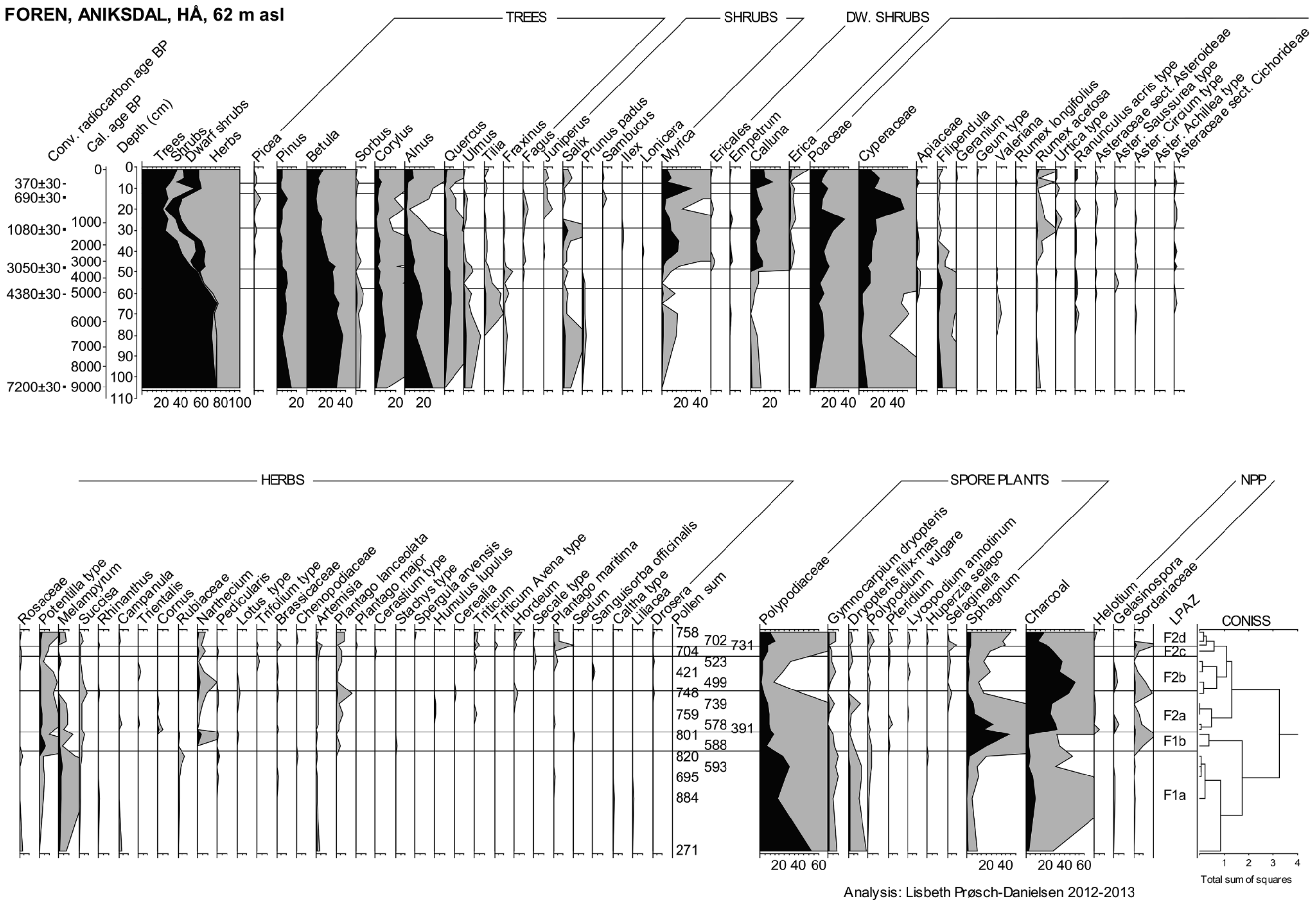

Fig. 6. Pollen percentage diagram from the Foren site (62 m asl), situated in the present day infield area at Aniksdal, Hå municipality, southwestern Norway.

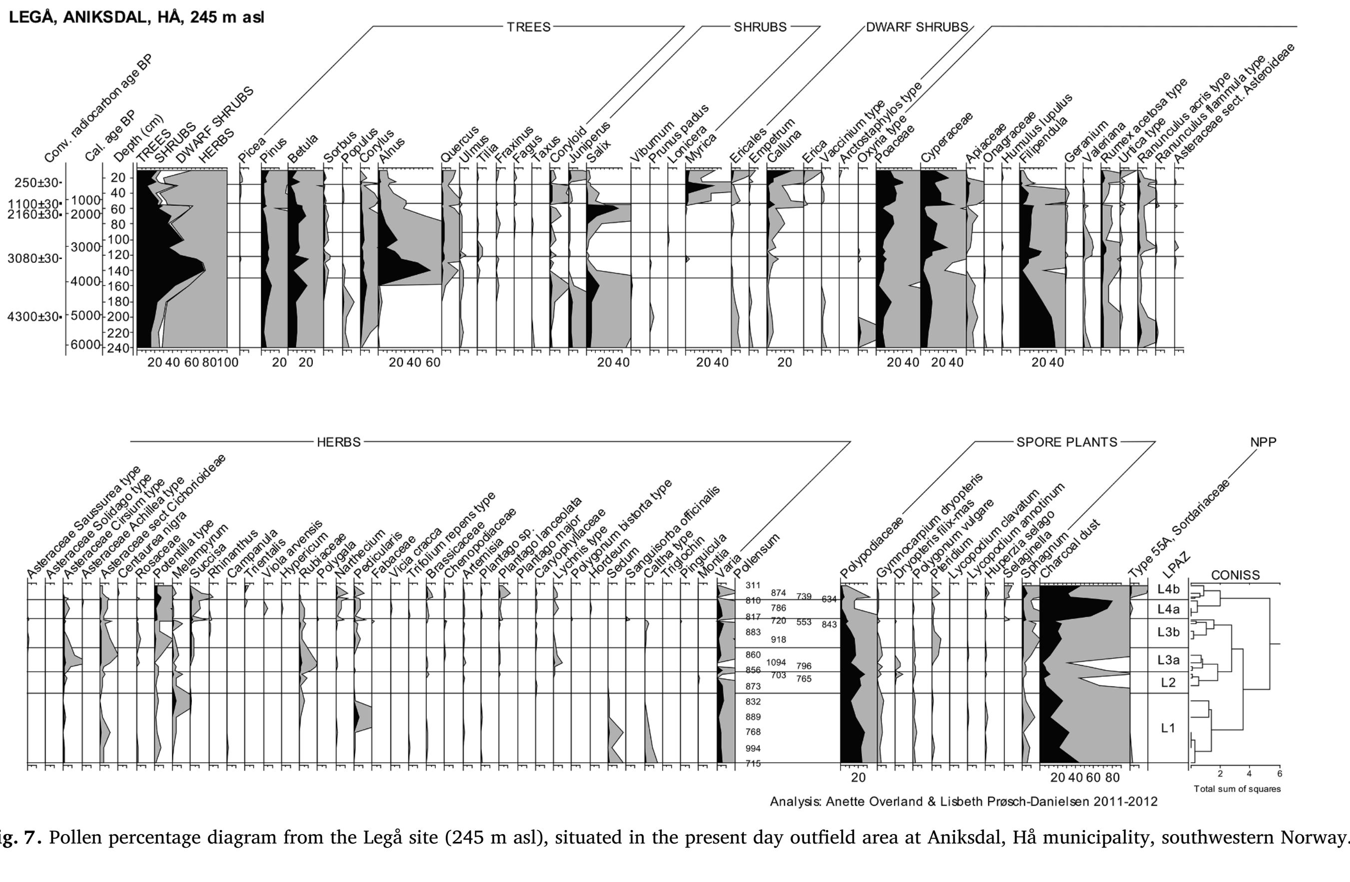

Fig. 7. Pollen percentage diagram from the Legå site (245 m asl), situated in the present day outfield area at Aniksdal, Hå municipality, southwestern Norway.

(approx. 20–40%).

L2 (*c*. 2200–1300 BCE): *Alnus* increased substantially, while shrubs and herbs declined. The amount of microscopic charcoal was at a minimum (approx. 5%).

L3a (*c*. 1300–500 BCE): *Alnus* decreased during this time interval, while grassland taxa increased, such as *Rumex acetosa*-type, *Ranunculus acris*-type, *Cirsium*, Rubiaceae, *Lychnis*-type and Cyperaceae. Microscopic charcoal levels increased slightly. A few pollen grains of *Plantago lanceolata* and *Succisa* were also identified.

L3b (c. 500 BCE–1000 CE): The pollen composition was dominated by the shrub *Salix,* while herb taxa decreased during this period. A single pollen grain of *Hordeum* was recorded and the content of microscopic charcoal increased to approx. 20%.

L4a (*c*. 1000–1700 CE): This period had high values of microscopic charcoal (up to approx. 80%) and was dominated by the shrub *Myrica* and grassland taxa, such as Poaceae, Cyperaceae, *Ranunculus acris*-type and *Potentilla*-type. The herbaceous composition was relatively rich, with taxa such as *Vicia cracca*, Asteraceae, *Achillea, Pedicularis*, *Narthecium ossifragum, Succisa*, Brassicaceae, *Plantago lanceolata* and *Trifolium repens.* Pollen from *Hordeum* and coprophilous fungal spores of Sordariaceae were also identified.

L4b (*c*. 1700 CE–present): The content of microscopic charcoal dropped to approx. 35% during this period, while the highest values of *Plantago lanceolata*, *Urtica*-type and Sordariaceae were recorded. Pollen of *Centaurea nigra* were also identified.

5.3. Regional vegetation cover based on the REVEALS model using all sites

The region was dominated by an open landscape throughout the studied period (4500 BCE–2000 CE) (Fig. 8). The tree and shrub cover was approx. 40% in the time interval 4500–4000 BCE and decreased almost continuously to approx. 10% in the most recent period. The dwarf shrub *Calluna vulgaris* covered approx. 5% in the oldest period and increased to approx. 35% during the following *c*. 500–1000 years, and remained at a high level (approx. 20–55%) until present. The maximum extent of *Calluna vulgaris* (55%) was 1000–500 BCE. Poaceae and Cyperaceae covered together between approx. 25–55% of the vegetation cover in all time intervals. *Filipendula* and *Rumex* had maximum cover between 4000 and 1000 BCE, with 4–11% combined. Meanwhile, *Plantago lanceolata* was present from 4000 BCE and increased to 0.5–0.7% between 1 and 2000 CE, with maximum cover 500–1000 CE. Cerealia were recorded from 500 BCE, and varied between 0.1 and 1.2% cover, with the highest value in the most recent period.

5.4. Local vegetation cover around each site based on the LOVE model

At *Foren*, trees and shrubs constituted approx. 70% of the vegetation cover and Poaceae approx. 20–30% from 4500 to 2500 BCE (Figs. 9 and 10). The most common trees were *Betula* and *Quercus*, followed by *Alnus*, *Corylus* and *Tilia.* From 2500 BCE, open land taxa (dominated by Poaceae and Cyperaceae) expanded and by the time window 1500–1000 BCE reached 70% cover together. Simultaneously, microscopic charcoal increased to approx. 30%. Maximum open land (approx. 90% cover) was in the time interval 1000–1500 CE. *Plantago lanceolata* was present from 2500 BCE and had a relatively variable cover. The highest cover of *Plantago lanceolata* was reached 500 BCE–1 CE (approx. 3% cover) and 500–1000 CE (approx. 4% cover), followed by a peak in microscopic charcoal (up to 50%). The Cerealia cover partly followed the increases of *Plantago lanceolata.* Cerealia were present from 500 BCE and the cover was rather variable. Peaks in Cerealia cover occurred 500–1 BCE (approx. 2% cover), 500–1000 CE (approx. 2% cover) and 1500–2000 CE (approx. 5% cover).

At *Stølabekken*, in the time window 3000–2500 BCE the tree cover was approx. 65%, and Poaceae cover was approx. 35%. From 2500 BCE, open land taxa, in particular Poaceae, expanded to more than 50% cover. Maximum open land (approx. 80% cover) was reached in the time intervals 500–1 BCE and 500 CE until present. *Plantago lanceolata* was present from 3000 BCE, with highest cover between 500 BCE and 2000 CE (approx. 1.5–2.5%). A peak in microscopic charcoal (approx. 35%) occurred around 1700 BCE.

At *Lensmannsslåttå, Alnus* dominated the vegetation*,* with up to 40–65% from 4000 to 2500 BCE. *Rumex* and *Filipendula* covered a large part of the landscape 4000–1500 BCE (approx. 20–45% cover combined). In the interval 2000–1500 BCE, Cyperaceae, Poaceae and *Rumex* dominated. From 1500 BCE to 1 CE, the most common tree was *Betula*, while Poaceae dominated the herb composition. *Calluna vulgaris* expanded in the 1000–500 BCE interval (together with a rise in microscopic charcoal to 20%), followed by a decline in the following time window. *Calluna vulgaris* became the dominant species (greater than 55% cover) from 1 CE when trees became almost absent. Maximum heathland cover (99%) was reached in the time window 500–1000 CE. From 1000 CE to present, Poaceae and Cyperaceae together covered approx. 20–30% of the vegetation. *Plantago lanceolata* was present from

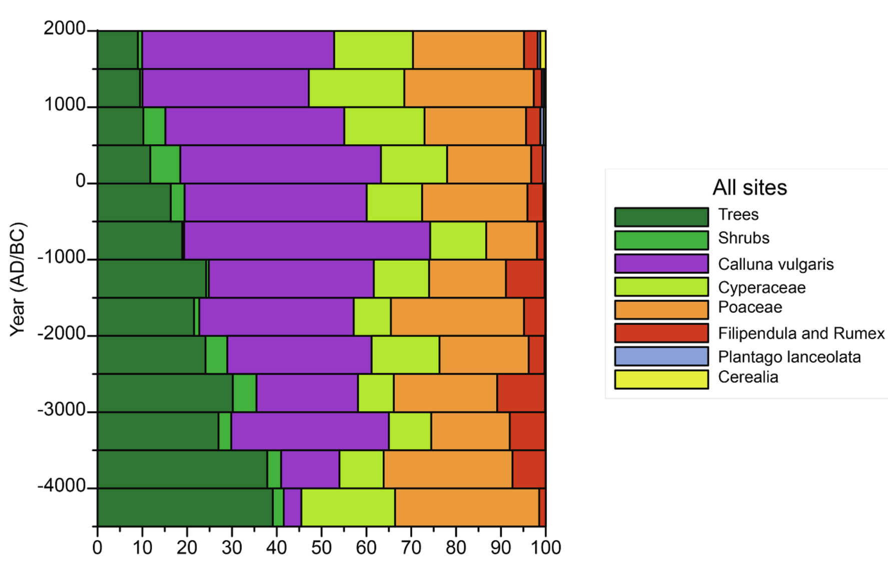

Fig. 8. REVEALS-based regional vegetation cover estimates based on all pollen records from the study area combined. Trees include *Alnus*, *Betula*, *Corylus, Fraxinus*, *Pinus*, *Quercus*, *Tilia* and *Ulmus*, while shrubs include *Juniperus* and *Salix*.

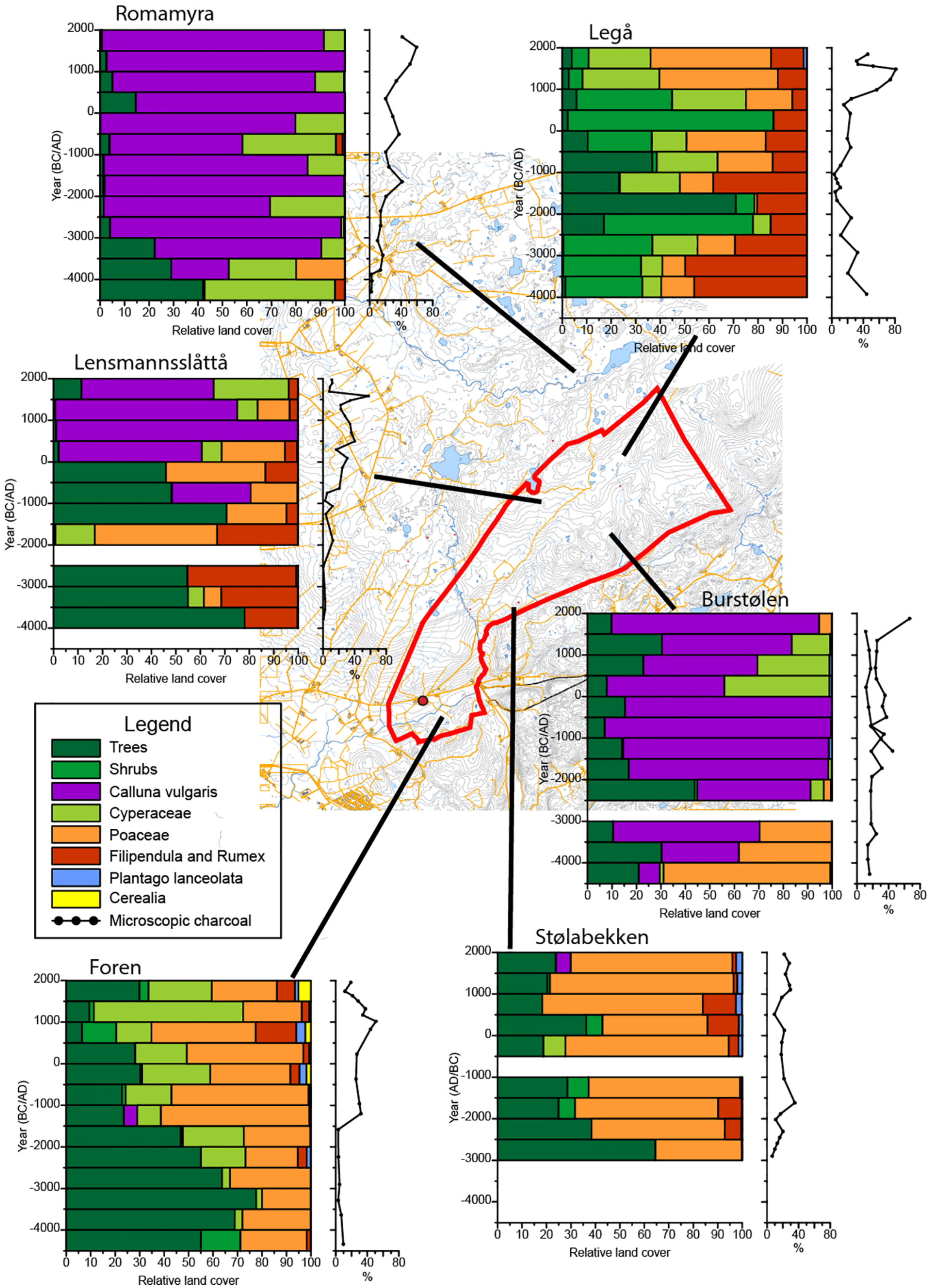

Fig. 9. LOVE-based estimates of local vegetation cover around each pollen site, along with the amount of microscopic charcoal. Trees include *Alnus*, *Betula*, *Corylus*, *Fraxinus*, *Pinus*, *Quercus*, *Tilia* and *Ulmus*, while shrubs include *Juniperus* and *Salix*.

4000 BCE and in most of the following time windows.

At *Burstølen,* Poaceae dominated the vegetation in the time window 4500–4000 BCE with approx. 70% cover, while trees covered approx. 20% (mainly *Corylus, Alnus* and *Quercus*) and *Calluna vulgaris* covered approx. 10%. From 4000 BCE, *Calluna vulgaris* expanded at the expense of Poaceae, and from 2000 BCE to 1 CE heathland covered more than 80%. This heathland expansion was accompanied by a slight increase (up to approx. 30%) in microscopic charcoal. Cyperaceae became common at the site from 1 to 1500 CE (approx. 15–40%). *Plantago lanceolata* was present from 3500 BCE, with a maximum cover of

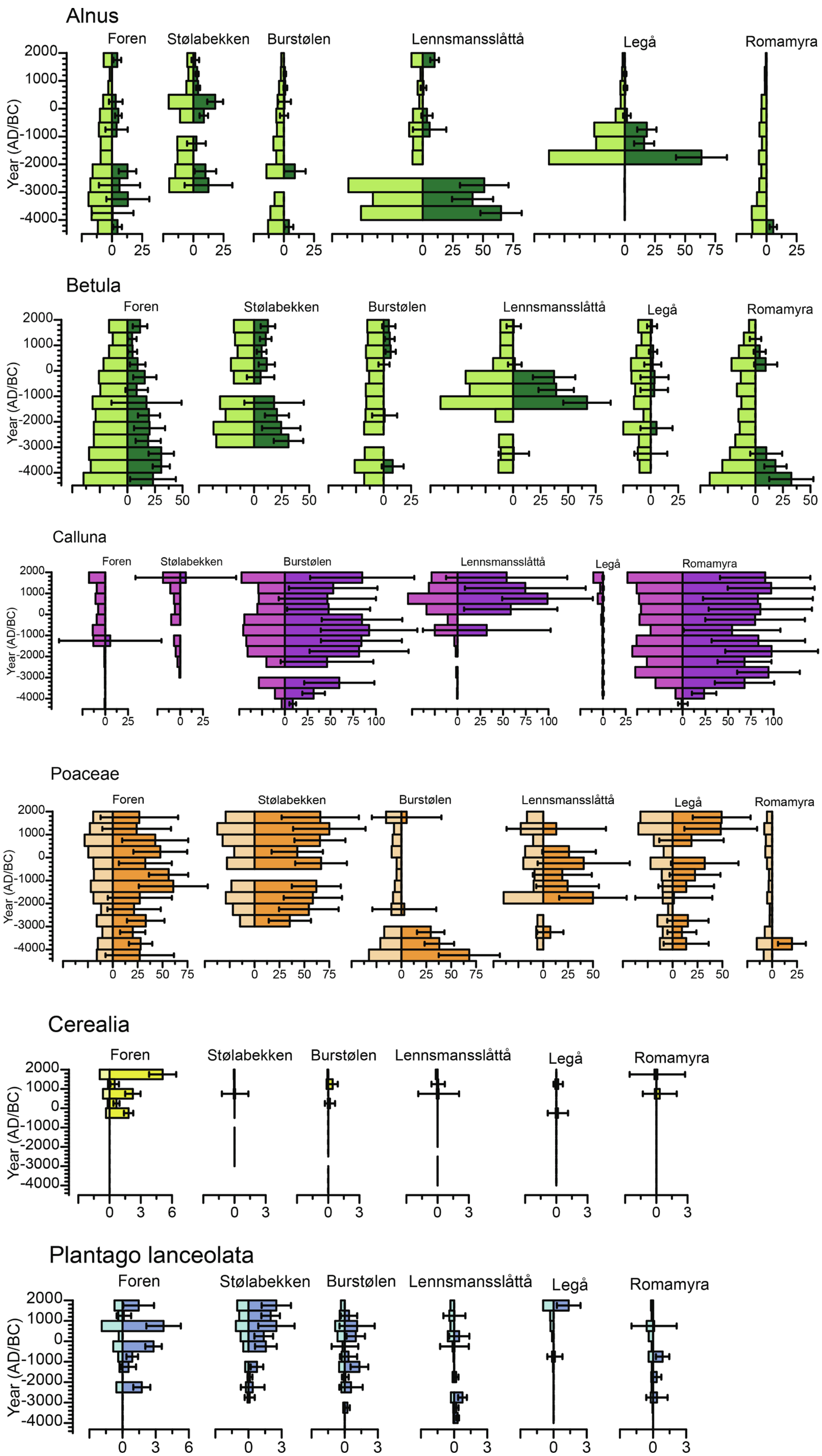

Fig. 10. Pollen percentage data (left side) compared to estimated local vegetation cover based on the LOVE model (right side) for selected taxa.

approx. 1–1.3% in the time intervals 1500–1000 BCE, and from 1–1000 CE. *Calluna vulgaris* expanded in the most recent time window, when also microscopic charcoal reached its maximum of approx. 70%.

At *Legå*, the shrubs *Juniperus* (approx. 10–15% cover) and *Salix* (approx. 15–25% cover) dominated the vegetation cover between 4000 and 2500 BCE, along with the herbs *Rumex* (approx. 5–15% cover) and *Filipendula* (approx. 25–35% cover). *Salix* increased in cover in the time interval 2500–2000 BCE (to approx. 60% cover) and *Alnus* expanded in the following interval 2000–1500 BCE (to approx. 65% cover), while *Salix* declined. Open land increased between 1500 and 1 BCE to approx. 65–75% cover. *Salix* expanded again between 500 BCE and 1000 CE; in particular 1–500 CE when it reached approx. 85% cover. From 1000 CE to present, open land taxa covered approx. 90%, dominated by Cyperaceae (approx. 25–30% cover) and Poaceae (approx. 50% cover), along with high amounts of microscopic charcoal (up to approx. 80%).

At *Romamyra*, in the time window 4500–4000 BCE, Cyperaceae covered approx. 55%, trees approx. 40% and *Rumex* approx. 4%. From 4000 BCE, *Calluna vulgaris* expanded substantially, from being almost absent to approx. 95% cover in the time window 3000–2500 BCE, and thereafter continued to dominate the vegetation at the site. The heathland expansion was accompanied by an increase in microscopic charcoal, with peaks at *c*. 1500 BCE, *c*. 500 BCE and during the last 500 years with up to 60%. The cover of Cyperaceae was rather variable and reached approx. 40% cover in the time window 1000–500 BCE. *Plantago lanceolata* was present from c. 3500 BCE.

6. Discussion

6.1. Late Mesolithic, 4500–4000 BCE

Arbitrarily collected lithics found in the valley at Aniksdal and around the lakes of Holmavatn and Storamos indicate hunting and fishing settlements on the Høg-Jæren Plateau during the Late Mesolithic, generally interpreted in terms of patterns of seasonal utilization (Bang-Andersen, 1973, 1979, 2005; Prøsch-Danielsen and Fyllingsnes, 2013). The REVEALS-output indicates a predominantly open landscape at Høg-Jæren in the Mesolithic (approx. 58% open land), which is unusual in pollen records for this period (Fig. 8). Only three additional pollen records from the southwestern coast of Norway show a partly open landscape in the Mesolithic (Prøsch-Danielsen and Simonsen, 2000a). A region further north along the west coast of Norway (approx. 250 km north of the study area) also shows a relatively open landscape (Hjelle et al., 2018). Heathland is recorded at Høg-Jæren with a regional cover of approx. 4% (Fig. 8). *Calluna vulgaris* is generally found along the west coast of Norway during the Late Mesolithic with a cover of approx. 0.1–5% (Hjelle et al., 2018). Vegetation changes in the Neolithic are conventionally related to various models of agriculture, though parts of southern Norway's landscape were open with patches of grass- and heathland, and *Plantago lanceolata* occurred already in the Late Mesolithic – before any possible introduction of agriculture (Glørstad, 2009; Hjelle et al., 2018: 409; Indrelid and Moe, 1983; Prøsch-Danielsen and Simonsen, 2000a; Selsing, 2016).

All settlements, also Mesolithic, entails clearance, burning and environmental impact (Stephens et al., 2019), but the evidence for human impact on the vegetation is limited at Høg-Jæren. However, at the Burstølen site, a small amount of *Calluna* cover (approx. 9% according to the LOVE-output) along with some microscopic charcoal (16%) possibly relates to active management, including the use of fire (Figs. 9 and 10). It has been argued that Mesolithic hunter-gatherers in Norway deliberately cleared and managed some areas with fire to attract wild animals and to improve productivity of plant resources (Mason, 2000; Selsing, 2016; Vera, 2000; Prescott, 2020). *Corylus* (hazelnut) favoured open land, and according to the pollen records, some hazel was present in low levels at Foren, Burstølen and Romamyra during the Late Mesolithic. The relatively open landscape at Høg-Jæren can also be explained by the undulating topography, i.e. by wetland development in the depressions, which prevented woodland to expand (Knudsen et al., 2006). The topography also generated variations in nutrient supply by erosion, explaining some of the differences in local landcover between sites, such as the development towards either grass- or heathland.

6.2. Early and Middle Neolithic, 4000–2500/2350 BCE

Flint artefacts collected around the lakes of Storamos and Holmavatn on the Høg-Jæren Plateau suggest that hunter-gatherer settlement continued into the Early to Middle Neolithic A (3950–2750 BCE) (Bang-Andersen, 1973; Prøsch-Danielsen and Fyllingsnes, 2013). One excavated site indicates an Early Neolithic age based on a radiocarbon date (*c*. 3800 BCE) and flint artefacts (Bang-Andersen, 1973, 1979, 2005). Hazelnut shells from the excavated site indicate collecting from nearby stands of *Corylus* or possibly from stands at lower altitudes. Bang-Andersen (1979:196) suggested a network of seasonal hunter-gatherer settlements during the Early Neolithic extending from the outer coast to the inland, possibly into the mountain regions of the interior. The glacial moraines that run though the uplands, are the first snow-bare areas in the spring, and provide a well-drained passageway through the otherwise boggy landscape (Fig. 2).

The pollen records suggest expansion of heathland on the Høg-Jæren Plateau during the Early and Middle Neolithic at the expense of trees, in particular at the Romamyra and Burstølen sites, where *Calluna* increased to approx. 24–94 and 32–60% cover, respectively (according to the LOVE-model) (Figs. 9 and 10). The increase in *Calluna* cover at Romamyra is accompanied by increased levels of microscopic charcoal (to approx. 15%), which may indicate anthropogenically induced fire to create open land at this site. An increase in open land follows the regional trend, i.e. several sites indicate expanded heath- and grassland along the west coast of Norway from the Neolithic (Hjelle et al., 2018; Prøsch-Danielsen and Simonsen, 2000a).

Plantago lanceolata sporadically appears in the pollen record during the Early to Middle Neolithic at four of the studied sites (Stølabekken, Burstølen, Lennsmansslåttå and Romamyra). Generally regarded as a grazing indicator (Behre, 1981; Nielsen et al., 2012) (Fig. 10), a study of contemporary western Norwegian grassland has shown that *Plantago lanceolata* correlates with both hay-meadows and pastures (Hjelle, 1999; Hjelle et al., 2006). Nevertheless, minor occurrences of grazing indicators do not necessarily entail grazing at the sampling site, as all human settlement impacts vegetation. *Plantago lanceolata* occured naturally on the coast before the Neolithic, and pollen can be transported through non-human agencies, e.g. from the lowlands to the uplands by the wind or with animals (Hjelle and Overland, 2001; Indrelid and Moe, 1983; Moe, 1973, 1983, 2014:172; Moe and van der Knaap, 1990; Potthoff, 2007:203).

Traditionally, increased open land and the occurrence of *Plantago lanceolata* are interpreted as an expression of the long-term evolutionary trajectory towards agriculture in the Neolithic period. An alternative interpretation emphasizes hunter-gatherer agency as a possible factor on the Høg-Jæren Plateau, and the question is whether the combined data represent hunter-gatherers experimenting with mobile livestock herding, or if the record is best interpreted as hunter-gatherers continuing management practices (for example, clearing areas to favour wild animals and plants) established in the Late Mesolithic.

6.3. Late Neolithic and Early Bronze Age (period I), 2500/2350–1500 BCE

Stray finds from these periods have been recovered from the study area (www.unimus.no). Recovered bone and flint material from the excavated site at Rugland (2 km north of the present farm Aniksdal) suggest a Late Neolithic age, probably related to a permanent farming settlement (Bakkevig, 1982; Lindblom, 1982; Simonsen et al., 1982). This evidence fits with the general trend in western Norway of the establishment and expansion of a farm society, exhibiting crop cultivation, animal husbandry, permanent settlements and long houses (Austvoll, 2020; Myhre, 2004; Prescott, 2005; Prøsch-Danielsen et al., 2018). The regional pollen records also show a pronounced period with forest clearance during the Late Neolithic (*c*. 2500–2200 BCE) (Hjelle et al., 2018; Prøsch-Danielsen and Simonsen, 2000a).

The pollen record from the Foren site is characterized by the first occurrences of *Plantago lanceolata*, which together with increased cover of Cyperaceae (i.e. slightly increased open land), indicate grazing in the valley (Figs. 6, 9 and 10). In the uplands, grassland increased at the Stølabekken and Lensmannsslåttå sites, while heathland expanded at the Burstølen and Romamyra sites, which suggests extensive areas used for pasturing (Figs. 9 and 10). The grass- and heathland expansions were generally accompanied with increased amounts of microscopic charcoal, which suggest fire-based management regimes. However, the pollen records from the Legå site shows an opposite trend, with increased cover of trees and shrubs, along with a decline in the amount of microscopic charcoal towards the end of the period (Figs. 7 and 9). These differences indicate that the intensity of land-use varied across the uplands, i.e. some areas were intensively used for grazing, while others were allowed to regrow. It is likely that the uplands were exploited on a seasonal basis, with shepherds minding the animals through the summer, i.e. transhumance was practiced between the lowland farms and the upland pastures, a practice generally established in western Norway during this period (Indrelid, 1994; Prescott, 1995).

6.4. Early and Late Bronze Age (period II-VI), 1500–500 BCE

Cultivated fields in the Late Neolithic and Bronze Age are generally thought to be more small-scale than in later periods, and therefore less likely to be identified in the pollen record. However, in the Bronze Age, the pollen record from Foren shows a substantial expansion of grassland at the expense of woodland, accompanied by a prominent increase in microscopic charcoal (to approx. 30%) and occurrences of *Plantago lanceolata* (Figs. 6 and 9). These changes indicate that a settlement was established in the valley near the Foren sampling site, although cereal pollen indicative of cultivation have not yet been recorded. Stray finds in the area also support human presence during the Bronze Age interval (www.unimus.no).

At Legå, the increased amount of open land taxa (approx. 70% cover according the LOVE model), along with an increased number of herbs, such as *Rumex acetosa*-type and *Ranunculus acris*-type, suggest a reopening of the landscape around this site (Figs. 7 and 9). The relatively high levels of microscopic charcoal at the grass-dominated sites (Foren, Stølabekken and Legå) and the heathland dominated sites (Romamyra and Burstølen) indicate active fire management to improve grazing for the livestock. At Lensmannsslåttå, the heathland seems to have expanded simultaneously with the increased amount of microscopic charcoal in the end of this period (Fig. 9). Fire management at several locations on the Høg-Jæren Plateau is also suggested by charcoal layers in soil profiles and beneath a clearance cairn; four of them dated to *c*. 1400–900 BCE (Table 2). Several upland research projects have suggested seasonal pasturing throughout westerly Norway during this period (Diinhoff, 2005; Hjelle et al., 2015a; Kvamme, 1988; Prescott, 1995; Prescott and Melheim, 2017; Skrede, 2005).

6.5. Iron Age (until Viking Age), c. 500 BCE–800 CE

Several typologically dated Iron Age settlements are recorded in the southern part of the valley where the modern farm Aniksdal is located, as well as in the neighbouring valleys (www.unimus.no), which suggest expansion of settlements and human activity during this time period (Fig. 2). Dates from the excavated Kvednabråde site suggest both Pre-Roman and Roman Iron Age phases (*c*. 200–100 BCE and *c*. 300 CE) (Lillehammer and Andreasen, 1973/74; Prøsch-Danielsen and Fyllingsnes, 2013). Stray finds from the Iron Age are mainly assigned to the Roman Iron Age and more commonly from the ensuing Migration Period (400–600 CE) (www.unimus.no; Helliesen 1898; Kristoffersen, 2000; Lillehammer, 1977).

The first cereal pollen are recorded from the study area. At Foren, the pollen record supports a permanent settlement in the floor of the valley, based on a substantial expansion of crop cultivation at *c*. 500–1 BCE (to approx. 2% cover according to the LOVE model), along with increased amounts of grassland indicators, such as *Plantago lanceolata* and *Rumex acetosa*-type, and with continued high levels of microscopic charcoal (Figs. 6 and 9).

In the uplands, two sites with house structures at Rindarhagen and Rinden seem to have been a small farm and a storage house, respectively, and could originate in the Iron Age. A clearance cairn near Rinden, dated to *c*. 100 CE, provides an indication of the age of the first building phase nearby (Prøsch-Danielsen and Fyllingsnes, 2013). It is also possible that some of the haystack foundations and clearance cairns identified in the uplands could be from this period. The farm at Rindarhagen, in this marginal environment, suggests a period of strong demographic pressure, such as the Migration Period or the Medieval Period. The latter is more likely as several other structures in the surroundings are dated to the Medieval Period (Prøsch-Danielsen and Fyllingsnes, 2013).

The pollen diagram from Legå (near Rindarhagen) indicates variable land-use, with an increased shrub cover in the middle of this period (1–500 CE), followed by renewed vegetation clearance. The microscopic charcoal also increased (to approx. 20%), and a single pollen grain of *Hordeum* was recorded, which can indicate cultivation nearby. The pollen diagram from Burstølen shows increases in *Plantago lanceolata* and *Rumex acetosa*-type, which suggests that pastoral activity expanded in the first 500 years CE (Fig. 9). During this time window, the cover of Cyperaceae also expanded (up to 40% cover according to the LOVE-model) at the expense of *Calluna vulgaris*, and possibly related to increasingly humid conditions around the site. At Lensmannsslåttå (approx. 400 m north of Rinden), increased grazing activity is indicated by expanding grassland, followed by expanded heathland and an increased amount of microscopic charcoal related to heathland management. An intensification of livestock grazing in the Early Iron Age is in accordance with records from other west Norwegian upland areas (Høeg, 2011; Kvamme et al., 1992; Stene and Gustafson, 2011), as well as around sub-alpine shielings (Moe, 1996; Prøsch-Danielsen, 1990).

The expansion of crop cultivation (indicated by the increased cover of cereals around the Foren site) suggests the establishment of a rigid infield-outfield system, which is generally attributed to the Early Iron Age in western Norway (Fredh et al., 2018; Halvorsen and Hjelle, 2017; Holm et al., 2009; Lillehammer, 2007; Myhre, 2004; Soltvedt et al., 2007). Infield hay-meadows and cultivated fields were generally situated close to the farm, and outfield pastures were further away (Emanuelsson, 2009; Øye, 2005). The cultivated fields were permanent and required increased amounts of manure, supplied by animals kept indoors in the winter. The need for winter fodder led to an expansion of hay-meadows. The many haystack foundations identified in the outfields (Figs. 2 and 5) suggest that these areas, too, were used as a resource for animal fodder, some of which may originate from the Iron Age. The introduction of hay-meadows is supported by finds of iron scythes that were used to cut grass to make hay (Solberg, 2000).

6.6. Viking Age and Medieval Period, c. 800–1500 CE.

Settlements from the Viking Age and Medieval Period are generally found beneath modern buildings (Myhre, 1978:262; Rønneseth, 1974). The only finds in the study area from these periods are a sword dated to *c*. 800–900 CE and other typologically dated stray finds. Nevertheless, the archaeology suggests settlements in the valley, probably located at the present day farm Aniksdal (www.unimus.no). The pollen record from Foren shows maximum open land *c*. 1000–1300 CE along with a high amount of microscopic charcoal, which indicate a relatively intensive farming activity (the open land is estimated by the LOVE-model to be approx. 90% in the time window 1000–1500 CE) (Fig. 9). The Viking Age and the Early Medieval Period are generally characterized by population growth in southwestern Norway (Fyllingsnes, 2013:131). However, the cereal cover is relatively sparse and the microscopic charcoal content declines during the end of this period. This reduction of burning probably corresponds with general agricultural decline ensuing from the Black Death 1349–50 CE (Lunden, 2004).

The economic importance of uplands during the Medieval Period is indicated by their regulation in the Gulathing Law (from the 11th century) for southwest Norway, such as the use of haystacks (Larson, 2008:94; Lillehammer, 2004; Robberstad, 1969). A few haystack foundations with enclosures (three still visible today) are found in the lower part of *Engjane*, possibly related to the Viking Age and Medieval time periods (Figs. 2 and 5). The enclosures hindered livestock from eating the stored hay, which might suggest that pasturing animals were left unattended. One of these haystack foundations is close to the Stølabekken site, where the pollen record shows a short-lived peak in taxa indicative of grassland, such as *Achillea*-type and *Ranunculus acris*-type, followed by an increase in microscopic charcoal *c.* 1000 CE (Fig. 9 and Appendix D).

One of the haystacks at Rinden (also surrounded by an enclosure) is possibly from the Viking or Medieval Ages (Fig. 5A) (Prøsch-Danielsen and Fyllingsnes, 2013). Furthermore, it is possible that at least the youngest phase in the building at Rinden is Medieval due to lack of finds, as shielings from this period is normally without artefacts (Bjørgo et al., 1992; Magnus, 1986; Randers and Kvamme, 1992; Skrede, 2005; Stene, 2015; Svensson, 2015:292). A few large stones occupy the floor, suggesting a simple function like a barn for dry storage. The building structure could also have been used as a milking shed in the autumn or early spring during the annual movement of livestock to pastures further up the valley. Thus, a multi-altitude, seasonal system of mowing and grazing at Rinden in the early spring and autumn may have been practiced, and combined with a late maturing grassland in the upper part of *Engjane*. These types of multi-altitude systems were once common on farms in the west Norwegian fjords (Daugstad et al., 2014:252; Daugstad and Schippers, 2016; Magnus, 1986; Timberlid, 2015), but also in the Alps (Andres, 2016:161). The upland resources for pasturing and haymaking were essential for increasing the number of livestock, while keeping livestock indoors in the winter, and producing manure for the fields, were common practices in western Norway (Daugstad et al., 2014:254; Kupiec et al., 2016; Reinton 1955, 1957, 1961; Timberlid, 2015).

The pollen site at Legå shows expanding open land (approx. 90% according to the LOVE model), increased amounts of grassland herbs and microscopic charcoal, and occurrences of cereal pollen, which suggests an expansion in the uplands during this period (Figs. 7 and 9). Probably, a permanent farm was established at Rindarhagen and a shieling at Burstølen, for cereal cultivation, dairy farming and haymaking during the Medieval Period (Fig. 5B). The house remains at Burstølen were dated to the Early Medieval Period (*c.* 1200 CE), along with several other structures nearby which support this interpretation (Table 2) (Prøsch-Danielsen and Fyllingsnes, 2013). Burstølen is four km from the settlement at Aniksdal, but only 600 m from the settlement at Rindarhagen, and therefore probably related to the latter (Fig. 5B). The animal pen between Rindarhagen and Burstølen is dated to the same period as the house at Burstølen (Table 2). The permanent settlement at Rindarhagen was probably abandoned before 1500 CE, as it is not mentioned in historical documents from this time (Fyllingsnes, 2013:116). Human activity during the Medieval Period in the uplands is supported by evidence from other sites dated to this period (for example, the remains of a house at Lille Vandavatn and the settlement Håland; Fig. 2) (Prøsch-Danielsen and Fyllingsnes, 2013; Archaeological museum in Stavanger, Topographical archive).

6.7. Post Medieval Period, 1500 CE–present

After a significant decline in population as a result of the Black Death, the population in southwestern Norway expanded again and probably reached the Early Medieval levels during the 17th century (Fyllingsnes, 2013:114–117; Prøsch-Danielsen and Fyllingsnes, 2013:37, 39). An expansion after 1500 CE can be identified in the pollen record from Foren, mainly shown by the maximum extent of cereal cultivation (5% cover according to the LOVE-model in the 1500–2000 CE time window) close to the present day farm at Aniksdal (Figs. 9 and 10). Historical records mention several separate farming units at Aniksdal during the 19th century (Fyllingsnes, 2013).

The burnt layer in one of the building remains at the shieling in Stølabekk-knuden was dated to *c.* 1650–1950 CE. Local people did not know its use during the 20th century, which implies that this shieling was in use sometime during the 17th to the 19th century (Prøsch-Danielsen and Fyllingsnes, 2013). Two enclosures nearby this shieling suggest animal management; probably used for milking (Fig. 5C). As the shieling was only two km from the main farm in the valley floor, this would have enabled frequent transport of products for further processing. In Norway, the number of shielings reached a peak between 1600 and 1850 CE (Daugstad and Sæter, 2001; Solheim, 1942), but by the 1890s this practice had gone out of use in southwestern Norway (Grude, 1891).

Twenty haystack foundations, found along both sides of the Rinden moraine, suggest that haymaking was common in the uplands (Fig. 5A–C). The lack of fences around these haystack foundations implies that they were in use in a period when animals were shepherded (Prøsch-Danielsen and Fyllingsnes, 2013).

The pollen diagram from Legå suggests relatively intense grazing activity in the upper part of the study area, with approx. 90% open land (Figs. 7 and 9). Four shepherd's huts and several minor shelters are found in a belt approx. 4–5 km from the present farm Aniksdal; two of them are dated to the Post-Medieval Period (Table 2). Two other shepherd's huts from the neighbouring farm Ualand were in use until 1910 (Prøsch-Danielsen and Fyllingsnes, 2013). These remains suggest that the upper parts of the study area were reserved for herded animals.

Near the Lensmannsslåttå site, haystacks and barns for storing hay were in use in the *Engjane* outfields until 1910 (map from Aniksdalsnesjane, 1910). The outfields were shared between farmers from the low-lying coastal farms at least from the 19th century, in relation to peat and hay resources (Prøsch-Danielsen and Fyllingsnes, 2013). Interviews with previous farmers at Aniksdal revealed that the *Bumarka* and the lower part of the *Engjane* were used for cow pasture, the upper part of the *Engjane* was used for sheep pasture, and young cattle were allowed to graze in between.

According to Reinton (1969), our study area is located in the zone where shieling practices were dominated by hay-production for winter fodder during the 19th century. Indeed, the archaeological and palaeoecological records show that fodder production was common, but also that pasturing and dairy farming were important resources in the uplands.

Currently, many of the archaeological remains on the Høg-Jæren Plateau, such as hay-stack foundations and shielings, are relatively difficult to locate in the landscape. They have not been used by farmers for at least 100 years and have lost their connection to the modern agriculture (Lillehammer, 2004, 2007). Consequently, this type of cultural landscape is vulnerable to encroachment, such as expanding cultivation and industrial windmills, as these land-use types have become more profitable (Daugstad and Prøsch-Danielsen, 2017; Haavaldsen, 1999).

7. Conclusions

The combination of materials and methods used in this study provides a relatively detailed picture of land-use development and the use of upland resources at the farm Aniksdal and surrounding areas, situated within the coastal heathland in southwestern Norway. At times, the land-use patterns were rather complicated, with human activities adapted to different landscape properties, such as topography and soil conditions. The landscape hosted a mosaic of wetlands, dry heathlands and fresh grasslands, which provided a diverse set of resources.

The landscape was predominantly open (increased from 60 to 90% cover at the regional scale) and human activities were registered during all the periods studied, i.e. the last 6500 years. Local variations were significant, with a general development towards either heath- or grassland, often accompanied by raised levels of microscopic charcoal, which suggest active fire clearance and/or management of the landscape.

Hunter-gatherer settlements and production dominated the early part of the record (*c*. 4500–2400 BCE). Sometime between 3950 and 2400 BCE, the impact on the vegetation might represent experiments with livestock herding. However, it is also likely that there is continuity from the Mesolithic to the Neolithic, i.e. the impact of non-agriculturists on the landscape, including active management to promote open grazing for wild animals and certain plant species. An agricultural society was established at *c.* 2400 BCE, as indicated by the dated charcoal layers and nearby settlement remains. Animal husbandry dominated the land use of the Høg-Jæren Plateau until *c.* 500 BCE.

Farm settlements are recorded in the lower part of the valley during the Iron Age (*c*. 500 BCE–1000 CE), along with the introduction of permanent, fertilized fields, indicating agricultural intensification. This triggered an increase in demand for winter fodder also produced in the uplands. The last *c.* 1000 years were characterized by diverse outfield exploitation, primarily through the use of shielings as bases for grazing, hay production and dairy farming. Several archaeological remains related to these practices were identified. In addition, shepherds' huts (probably in use during the last *c*. 500 years) show the importance of shepherding for protecting the fodder stored in haystacks. Moreover, archaeological remains of haystack foundations and storage barns suggest that haymaking was one of the most important land-use components in the uplands during recent times. Indeed, a new type of shieling (from the 17th to the 19th centuries) was situated at a relatively low altitude close to the main farm, enabling daily transport of products from the uplands to the lower valley. If managed by traditional land-use practices (mainly grazing), the diverse cultural landscape and the archaeological remains on the Høg-Jæren Plateau can be viewed also in the future.

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Appendixes. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jasrep.2020.102443.

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