in Situ

Archaeologica

vol.14

in Situ Archaeologica

ISSN 2000-4044

www.insituarchaeologica.com

Artiklar i in Situ granskas av anonyma referenter i redaktionskommittén.

Finansiärer
Bohusläns museum, Göteborgs universitet, Kulturmiljö Halland,
Statens Historiska Museer Arkeologerna

in Situ Archaeologica

vol.14

Tema: Rogaland

in Situ
Archaeologica

in Situ vol.14
Sid 131-144
www.insituarchaeologica.com

ISSN 2000-4044

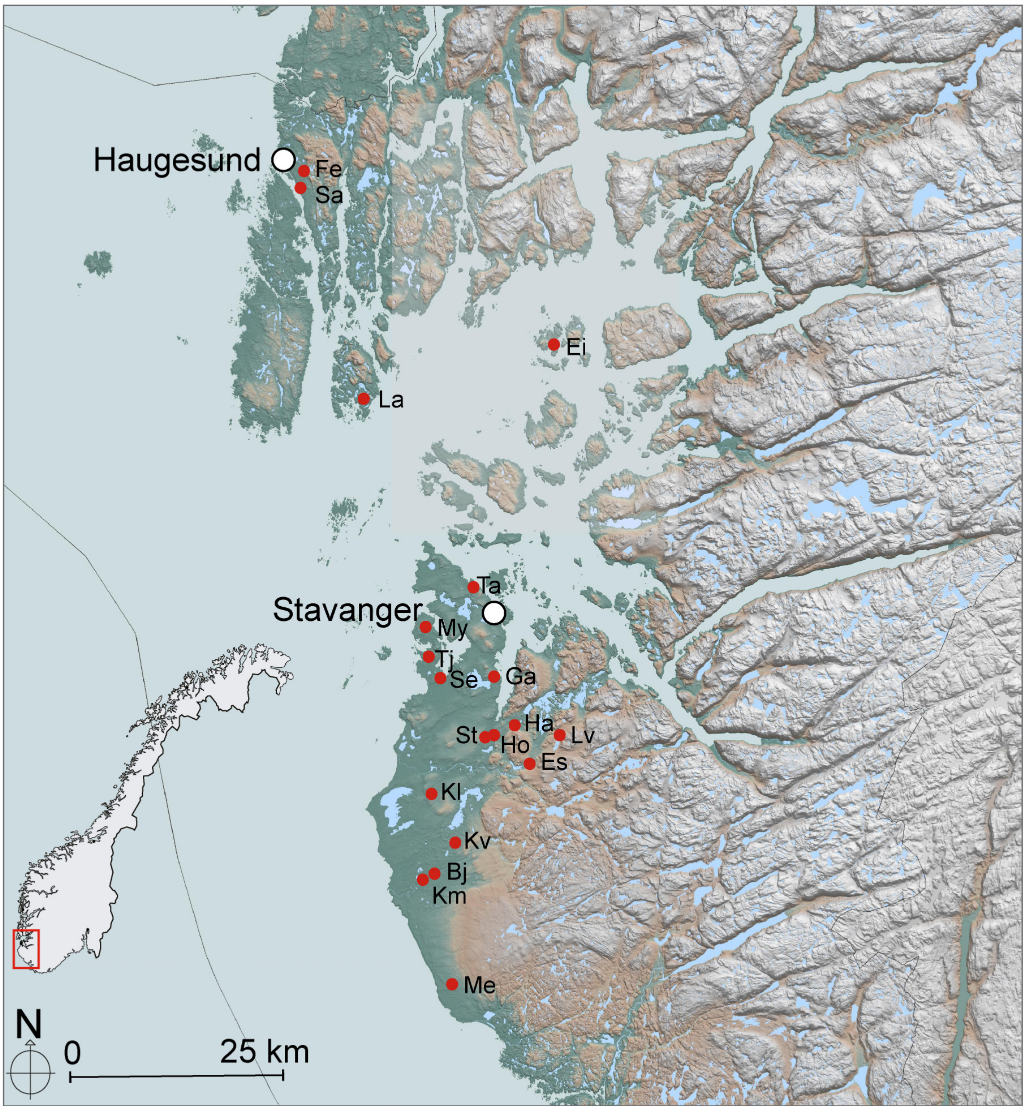
Christin Eldegard Jensen
Arkeologisk museum, Universitetet i Stavanger
christin.jensen@uis.no

Tema: Rogaland

Agrarian Storytellers

Pollen and Charred Plant Macrofossils of Ancient Field Layers

This paper offers a descriptive overview and main trends of pollen and macrofossil data obtained from 19 archaeological sites in Rogaland, SW Norway, excavated between 1998 and 2018. The dataset covers the period from late Neolithic until the Middle Ages. Pros and cons of the two botanical methods are discussed, concluding that there are clear advantages in joint application as there are significant differences in their statement value. Pollen and charred plant macrofossils function as complementary variables as they represent different biological stages of the same plant species, and because of differences in dispersal mechanisms and preservation in aerobic soils. The greater possibility to identify macrofossils of cereals and weeds to species and sub-species level is a strong advantage. By including pollen analysis, one achieves a higher total biodiversity, and by that the reflection of a wider environmental spectrum giving room for the inclusion of new issues in archaeological research.



1.
Map of Rogaland, South-western Norway with sites included in this study. See figure 2 for site abbreviations.

Introduction

Ideally, archaeological excavation and analysis should maintain a holistic perspective on past land use, which covers all aspects of human interactions with nature. The possibility of correlating on and off-site anthropogenic proxy signals with additional time control provided by the archaeological typological dating method, offers a multifaceted viewpoint, plus a more complete and thorough interpretation of past human settlement patterns (e.g. Fredh et al. 2018, Halvorsen & Hjelle 2017, Hjelle et al. 2012, Jensen 2020, Jensen & Arntzen 2016, Overland & Hjelle 2013, Prøsch-Danielsen & Soltvedt 2011, Sjögren & Arntzen 2013, Vorren et al. 1990). However, bureaucratic and economic constrictions often hinder this approach on archaeological investigations. The lack of deposits with good chronostratigraphic control and preservation conditions for biological matter, such as wetlands, within investigation areas is another limitation.

Charred plant macrofossils and pollen are the most frequently used proxy parameters because they are least susceptible to oxygen damage. They represent different biological stages of the mother plants and complement each other to give a clearer picture of the past (Halvorsen and Hjelle, 2017). The value of pollen analysis on archaeological contexts with dry soils has been disputed by palaeobotanists and archaeologists (Dimbleby 1985) but is now often implemented on projects. Fredh et al. (2018) demonstrates the potential of pollen data from buried field contexts for reconstructing the agricultural development of Rogaland.

Ancient cultivation layers represent a key data source for understanding local agricultural activity and are important providers of ^{14}C-dates. In comparison with house contexts, which may contain a selection of plant macrofossils related to food processing or ritual activities, fields were the actual locations where the cultivation process occurred. However, fields are subjected to primary and secondary processes that influence taphonomy and challenge interpretation of the botanical finds.

My aim is to systematically test the correlation between pollen and charred plant macrofossils in cultivation layers from Rogaland with respect to taxonomic diversity, cultivation impact and age.

Archaeological site	Abbr.	Municipality	*Geographical coordinates (lat./long.)	Mean alt. (m a.s.l.)	No. of layers	No. of samples Pollen/macro	Reference
1.Bjorhaug	Bj	Hå	58°40’07” N/05°79’13” E	39	2	4/2	Westling & Fredh 2014
2.Eik	Ei	Finnøy	59°15’12” N/05°48’59” E	23	3	5/3	Jensen et al. 2015
3.Espeland	Es	Sandnes	58°48’49” N/05°49’10” E	60	2	6/4	Fredh and Mooney 2020
4.Fedjedalen	Fe	Haugesund	59°24’32” N/05°20’10” E	55	1	1/1	Soltvedt & Tjemsland 2017
5.Gausel	Ga	Stavanger	58°54’41” N/05°44’58” E	65	2	4/3	Solem 2001 (pollen), Børsheim & Soltvedt 2002 (macro)
6.Hana	Ha	Sandnes	58°50’55” N/05°45’43” E	54	5	10/5	Lempiäinen-Avci &Tjemsland 2017
7.Hove	Ho	Sandnes	58°49’59” N/05° 43’59” E	34	6	16/7	Westling & Jensen 2020
8.Kleppevarden	Kl	Time	58°46’30” N/05° 37’03” E	44	6	21/9	Husvegg et al. 2015
9.Kvia-Motland	Km	Hå	58°39’17” N/05° 38’02” E	35	1	3/1	Westling & Overland 2012
10.Kvåle	Kv	Time	58°43’31” N/05°40’14” E	46	11	24/37	Soltvedt et al. 2007
11.Laupland	La	Bokn	59°11’06” N/05°26’49” E	19	2	3/3	Jensen & Soltvedt unpubl.
12.Leikvam	Lv	Sandnes	58°50’31” N/05°52’38” E	152	3	3/3	Fyllingen et al. 2019
13.Meland	Me	Hå	58°35’52” N/05°41’14” E	55	2	8/3	Jensen & Soltvedt 2011
14.Myklebust	My	Sola	58°56’56” N/05°35’14” E	36	4	5/4	Overland 2012 (pollen), Sandvik 2018 (macro)
15.Sakkastad	Sa	Haugesund	59°23’10” N/05°18’06” E	21	1	2/1	Bjørdal et al. 2019
16.Sømme IV	Se	Sola	58°53’39” N/05° 37’27” E	25	6	9/8	Jensen & Soltvedt unpubl.
17.Sørbøtunet	St	Sandnes	58°49’60” N/05° 43’24” E	45	3	10/7	Sandvik 1999 (macro), Westling & Jensen 2020 (pollen)
18.Tastarustå	Ta	Stavanger	58°59’ 12” N/05° 41’ 70”E	56	1	3/3	Soltvedt & Enevold 2009
19.Tjora	Tj	Sola	58°54’ 52” N/05° 35’ 59”E	25	7	15/14	Soltvedt & Jensen 2011
			Total number		68	152/118	

*www.norgeskart.no

2.

Sites included in the study of pollen and plant macrofossils from buried cultivation layers, listed alphabetically.

Material and methods

Pollen and charred plant macrofossil data from 68 ^{14}C-dated cultivation layers are compiled. The data was obtained from 19 archaeological sites, excavated between 1998 and 2018 (figures 1, 2). There is an overlap of 13 sites between the present study and that of Fredh et al. (2018). Most sites are located on good farmland with relatively thick till cover on the southern coastal plain of Rogaland, while four sites are from the northern outer coastal region. Only radiocarbon dated contexts clearly defined as cultivation layers during excavation, and with joint pollen and carbonized macrofossil analyses are included in the study (figures 2, 3). The standard procedure used at Am-UiS when sampling profiles from prehistoric fields is that, depending on thickness, one to three soil samples for macrofossil analysis are collected per layer, and at least two pollen samples per layer; therefore, the number of macrofossil and pollen samples from each site may differ. If more than one sample per layer, the average is used. The data is standardized so that only samples with a pollen sum >100 are included, and macrofossils per sample are adjusted to represent the number per 10 litres. Radiocarbon dates are calibrated using Oxcal v 4.3.2 (Bronk Ramsey 2017) and Intcal 13 atmospheric curve (Reimer et al 2013) (figure 4). Plant taxa are arranged in nine groups based on physiognomy and ecological preferences relevant for the interpretation of vegetation composition in a cultural landscape (figures 4, 5). Ecological gradients in the datasets are searched for by use of detrended correspondence analysis (DCA), principal components analysis (PCA, figure 6) and redundancy analysis (RDA) with taxa groups (compositional), age and site (nominal), as independent supplementary variables and explanatory environmental descriptors. Significance at $P \leq 0.05$ of axes and selected variables are tested by the Monte Carlo permutation test (999 permutations) and forward selection using Canoco 5 (ter Braak and Smilauer 2012).

Results

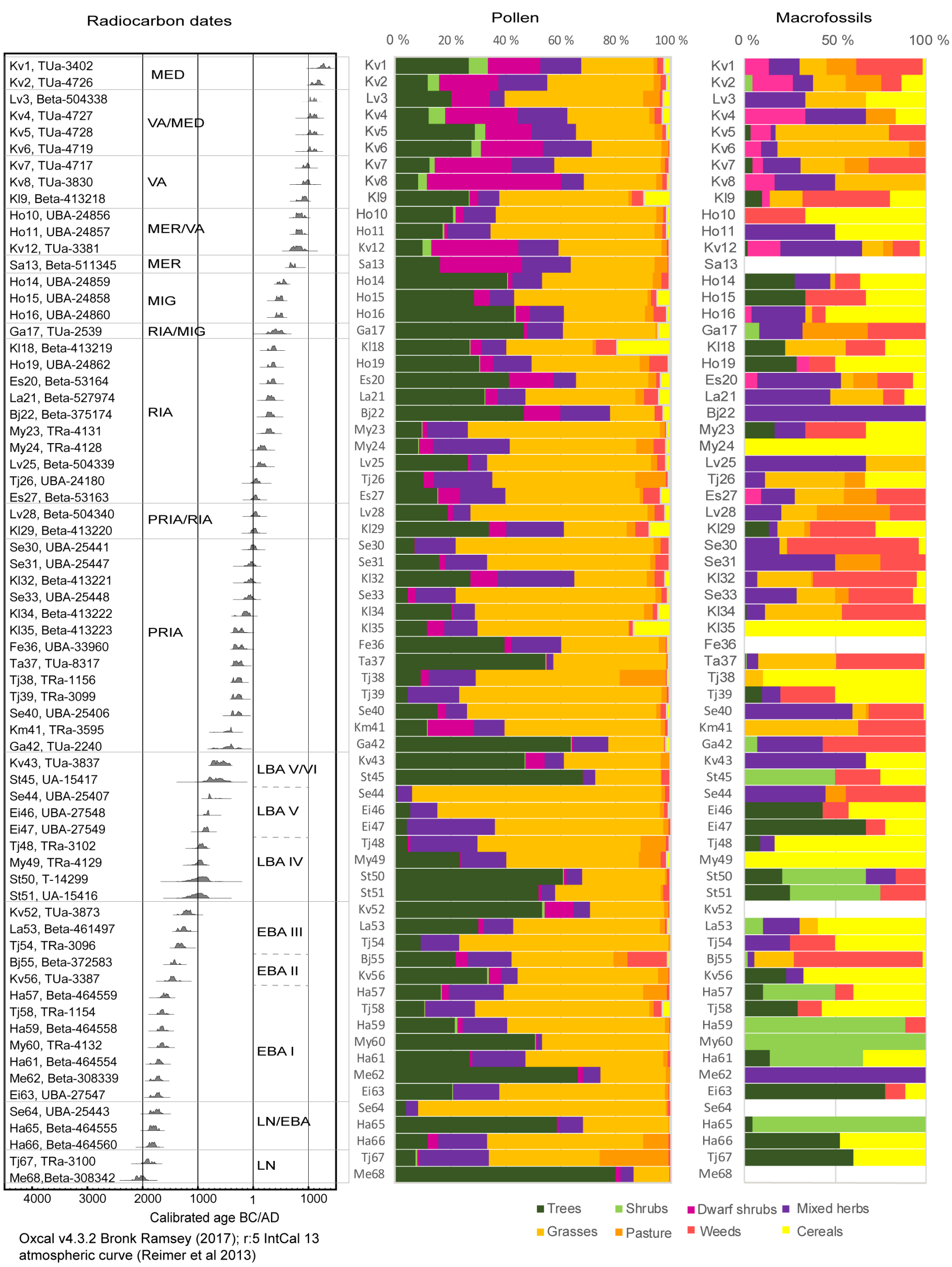
The period covered in this study is from LN (2300–1800 BC) until MED (AD 1250–1500) (figures 2, 3). Out of 68 layers, 38 are directly dated on charred cereal seeds. A majority of 13 layers are dated to PRIA, while RIA/MIG and MER are represented by one layer.

Altogether, only four layers lack observations of cereal diaspores, all older than the LBA V. Cereals and weeds are present merely as macrofossils in one layer

3. (next page)
Overview of buried cultivation layers with pollen and macrofossil samples and radiocarbon dates. Archaeological period abbreviations: MED (Middle Ages), VA (Viking Age), MER (Merovingian Period), MIG (Migration Period), RIA (Roman Iron Age), PRIA (Pre-Roman Iron Age), LBA (Late Bronze Age), EBA (Early Bronze Age), LN (Late Neolithic Period).

Layer no	Pollen sample abbreviation	Macrofossil sample abbreviation	Site & Lab-ID	^{14}C age BP	Calibrated age 2 sigma BC/AD from–to		Archaeol. period	Dated material
Bj55	BjP3-4	BjM15	Bj, Beta-372583	3150 ±30	-1500	-1311	EBA II	Charcoal (deciduous trees)
Bj22	BjP112-113	BjM116	Bj, Beta-375174	1740±30	236	386	RIA	Cereal (unspecified)
Ei63	EiP5-7	EiM20	Ei, UBA-27547	3431±32	-1877	-1643	EBA I	Cereal (unspecified)
Ei46	EiP30	EiM56	Ei, UBA-27548	2666±31	-896	-797	LBA V	Cereal, unspecified)
Ei47	EiP27	EiM57	Ei, UBA-27549	2705±36	-916	-804	LBA V	Cereal, unspecified)
Es27	EsP1-3	EsM5-6	Es, Beta-53163	1960±30	-40	120	RIA	Charcoal (Salix/Populus)
Es20	EsP8-10	EsM12-13	Es, Beta-53164*	1700±30	254	406	RIA	Charcoal (Corylus/Alnus)
Es20	EsP8-10	EsM12-13	Es, Beta-53165	1640±30	336	534	RIA/MIG	Charcoal (Betula)
Fe36	FeP7	FeM17	Fe, UBA-33960	2178±33	-354	-184	PRIA	Charcoal (twig unspecified)
Ga42	GaP36-37	GaM38	Ga, TUa-2240*	2340±60	-748	-208	LBA/PRIA	Charcoal (tree unspecified)
Ga42	GaP36-37	GaM38	Ga, TUa-2250	2345±60	-750	-210	LBA/PRIA	Fragments of straws
Ga17	GaP324-325	GaM330, 333	Ga, TUa-2539	1640±65	251	556	RIA/MIG	Seeds (Plantago lanceolata)
Ha66	HaP12-13	HaM19	Ha, Beta-464560	3510±30	-1918	-1748	LN/EBA	Nutshell (Corylus avellana)
Ha57	HaP9-10	HaM20	Ha, Beta-464559	3320±30	-1683	-1521	EBA I	Nutshell (Corylus avellana)
Ha59	HaP6-7	HaM21	Ha, Beta-464558	3360±30	-1700	-1607	EBA I	Seeds (Rubus idaeus)
Ha61	HaP4-5	HaM22	Ha, Beta-464554	3410±30	-1865	-1627	EBA I	Cereal (Hordeum vulgare var. vulgare)
Ha65	HaP1-2	HaM23	Ha, Beta-464555	3480±30	-1888	-1697	LN/EBA	Charcoal (Alnus)
Ho15	HoP122, 124	HoM127	Ho, UBA-24858	1592±23	413	538	MIG	Cereal (Hordeum vulgare var. vulgare)
Ho14	HoP120	HoM128	Ho, UBA-24859	1523±27	428	604	MIG	Cereal (Hordeum vulgare var. vulgare)
Ho16	HoP117-118	HoM129-130	Ho, UBA-24860*	1601±22	405	536	MIG	Cereal (Hordeum vulgare var. vulgare)
Ho16	HoP117-118	HoM129-130	Ho, UBA-24861	1600±22	405	536	MIG	Cereal (Hordeum vulgare var. vulgare)
Ho19	HoP111, 113, 115	HoM131	Ho, UBA-24862	1692±26	257	410	RIA	Cereal (Hordeum vulgare var. vulgare)
Ho10	HoP319-321	HoM323	Ho, UBA-24856	1175±29	770	962	MER/VA	Cereal (cf. Hordeum)
Ho11	HoP314-318	HoM324	Ho, UBA-24857	1183±22	771	937	MER/VA	Cereal (Hordeum)
Kl35	KlP78-81	KlM82	Kl, Beta-413223	2180±30	-361	-168	PRIA	Cereal (unspecified)
Kl9	KlP26, 28-29	KlM32-33	Kl, Beta-413218	1130±30	777	988	VA	Cereal (cf. Avena)
Kl18	KlP23-25	KlM34	Kl, Beta-413219	1680±30	258	422	RIA	Cereal (Hordeum vulgare var. vulgare)
Kl29	KlP15-16, 18, 20, 22	KlM35-36	Kl, Beta-413220	1980±30	-45	77	PRIA/RIA	Cereal (unspecified)
Kl32	KlP8, 9, 11, 13-14	KlM37-38	Kl, Beta-413221	2040±30	-162	46	PRIA	Cereal (Hordeum vulgare var. vulgare)
Kl34	KlP4	KlM39	Kl, Beta-413222	2110±30	-204	-46	PRIA	Cereal, (unspecified fragments)
Km41	KmP9, 11-12	KmM20	Km, TRa-3595	2355±35	-702	-368	PRIA	Straw fragments
Kv7	KvP154-156, 161	KvM163, 164, 176-177	Kv, TUa-4717	1070±30	895	1021	VA	Seeds (Danthonia decumbens)
Kv56	KvP388	KvM405-406	Kv, TUa-3387	3185±45	-1607	-1311	EBA II	Cereal (Hordeum vulgare var. vulgare + unspecifoed fragment)
Kv4	KvP233	KvM248	Kv, TUa-4727	975±40	995	1156	VA/MED	Cereal (Hordeum)
Kv2	KvP207-208, 210	KvM202, 222-223	Kv, TUa-4726	870±35	1044	1252	VA/MED	Cereal (Hordeum)
Kv8	KvP180, 182	KvM682-683	Kv, TUa-3830	1065±45	782	1115	VA	Twig fragments
Kv12	KvP263, 265	KvM678-681, 290, 292	Kv, TUa-3381	1220±60	669	961	MER/VA	Twig and straw fragments
Kv1	KvP563	KvM607, 591-592, 2325-2327	Kv, TUa-3402	735±65	1161	1395	MED	Cereal (unspecified)
Kv5	KvP601-603	KvM616-617,621, 623, 1020-1023	Kv, TUa-4728	985±40	989	1155	VA/MED	Twig and straw fragments
Kv6	KvP137, 139	KvM2169-2170	Kv, TUa-4719	990±35	986	1155	VA/MED	Charcoal (Salix)
Kv52	KvP141-142	KvM2173	Kv, TUa-3873	2975±35	-1369	-1056	EBA III	Charcoal (Betula)
Kv43	KvP1015-1017	KvM1008-1009	Kv, TUa-3403	2510±50	-798	-432	LBA/PRIA	Twig fragments
Kv43	KvP1015-1017	KvM1008-1009	Kv, TUa-3837*	2460±30	-758	-429	LBA/PRIA	Cereal (unspecified)
La53	LaP157	LaM167	Beta-461497	3020±30	-1385	-1130	EBA III	Cereal (Hordeum vulgare var. vulgare)
La21	LaP413, 415	LaM419-420	Beta-527974	1730±30	242	386	RIA	Cereal (unspecified)
Lv3	LvP21	LvM28	Lv, Beta-504338	970±30	1017	1154	VA/MED	Cereal (unspecified)
Lv25	LvP16	LvM29	Lv, Beta-504339	1870±30	73	226	RIA	Charcoal (Betula)
Lv28	LvP24	LvM30	Lv, Beta-504340	1960±30	-4	121	RIA	Charcoal (Betula)
Me62	MeP17-20	MeM28-29	Me, Beta-308340	3580±30	-2028	-1828	LN	Charcoal (Quercus)
Me62	MeP17-20	MeM28-29	Me, Beta-308339*	3430±30	-1876	-1643	EBA I	Charcoal (deciduous trees)
Me68	MeP21-22, 24-25	MeM30	Me, Beta-308342	3660±40	-2190	-1926	LN	Charcoal (deciduous trees)
My23	MyP283	MyM275	My, TRa-4131	1755±30	180	385	RIA	Cereal (Avena)
My60	MyP281	MyM277	My, TRa-4132	3355±35	-1741	-1533	EBA I	Charcoal (Betula/Alnus)
My24	MyP243-244	MyM249	My, TRa-4128	1855±30	82	234	RIA	Cereal (Hordeum vulgare var. vulgare)
My49	MyP240	MyM251	My, TRa-4129	2815±35	-1073	-850	LBA IV	Cereal (Hordeum)
Sa13	SaP72-73	SaM87	Sa, Beta-511345	1310±30	656	769	MER	Charcoal (Corylus/Alnus)
Se30	SeP39	SeM43-44	Se, UBA-25440	1981±28	-43	72	PRIA/RIA	Charcoal (deciduous trees + Ericaceae)
Se30	SeP39	SeM43-44	Se, UBA-25441*	2000±28	-52	66	PRIA/RIA	Charcoal (deciduous trees)
Se40	SeP32, 34	SeM46-47	Se, UBA-25406*	2258±34	-398	-207	PRIA	Cereal (unspecified)
Se40	SeP32, 34	SeM46-47	Se, UBA-25442	2288±28	-405	-232	PRIA	Charcoal (deciduous trees)
Se44	SeP28	SeM48	Se, UBA-25407	2585±35	-823	-559	LBA V/VI	Twig fragments
Se64	SeP26	SeM49	Se, UBA-25443	3442±39	-1881	-1661	LN/EBA	Charcoal (Betula)
Se33	SeP132	SeM145	Se, UBA-25448	2051±30	-165	17	PRIA	Charcoal (deciduous trees)
Se31	SeP134-136	SeM144	Se, UBA-25447	2031±32	-157	52	PRIA	Charcoal (deciduous trees)
St51	StP813, 815, 817, 819	StM14	St, UA-15416	2825±90	-1222	-811	LBA IV	Charcoal (Betula)
St50	StP87, 89, 811	StM10, 13, 16	St, UA-15415	3505±75	-2027	-1644	LN/EBA	Charcoal (Betula)
St50	StP87, 89, 811	StM10, 13, 16	St, T-14299*	2770±110	-1262	-770	LBA IV	Nutshell (Corylus)
St45	StP93, 95, 97	StM103-105	St, UA-15417	2570±90	-895	-415	LBA V/VI	Charcoal (deciduous trees)
Ta37	TaP47-49	TaM65, 367-368	Ta, TUa-8317	2200±30	-366	-192	PRIA	Seeds (Persicaria + Spergula arvensis)
Tj54	TjP234	TjM244	Tj, TRa-3096	3060±30	-1411	-1231	EBA III	Cereal (Hordeum)
Tj26	TjP281-282, 285-287	TjM715-716	Tj, UBA-24180	1947±35	-37	127	RIA	Cereal (Hordeum)
Tj48	TjP279-280	TjM717	Tj, TRa-3102	2785±35	-1012	-839	LBA IV	Cereal (Hordeum)
Tj58	TjP293-294	TjM368-369	Tj, TRa-1154	3355±30	-1740	-1535	EBA I	Cereal (Hordeum)
Tj38	TjP330-332	TjM383-386	Tj, TRa-1156	2230±25	-382	-205	PRIA	Cereal (Hordeum)
Tj67	TjP620	TjM638-639	Tj, TRa-3100	3560±35	-2021	-1773	LN	Cereal (Hordeum)
Tj39	TjP622	TjM636-637	Tj, TRa-3099	2240±30	-390	-205	PRIA	Cereal (Hordeum)

*Radiocarbon date used in ordinations when more than one date per layer



4.

Relative composition of groups of plant taxa reflected in the records of pollen and charred plant macrofossils. The results are presented as average per layer and in chronological order according to the calibrated ^{14}C-date of each layer. Note that macrofossil abundance is based on number per volume while the amount of pollen is based on percentages. The Trees group is only represented by Corylus nutshells among macrofossils.

Group	Total number pollen/macro	Joint representation	Separate representation: Pollen	Separate representation: Macrofossils
Trees	12/1	Corylus	Acer, Alnus, Betula, Fraxinus, Picea, Pinus, Populus, Quercus, Sorbus, Tilia, Ulmus	-
Shrubs	6/4	Myrica	Juniperus, Lonicera, Salix, Sambucus, Viburnum	Rubus caesius, Rubus idaeus, Sambucus nigra
Dwarf shrubs	4/2	Empetrum	Calluna, Ericaceae, Vaccinium	Arctostaphylos uva-ursi
Grasses	1/6	Poaceae	-	Alopecurus, Arrhenaterum, Bromus, Danthonia decumbens, Poa annua
Pasture	3/1	Plantago lanceolata	Trifolium repens type, Plantago major	-
Arable weeds	4/9	Fumaria, Persicaria, Spergula	Artemisia type	Chenopodium album, Gale-opsis, Persicaria lapathifolia, Persicaria maculosa, Raphanus raphanistrum, Stellaria media
Cereals	5/7	Avena, Cerealia indet., Hordeum, Secale	Triticum type	Hordeum v. var. nudum, Hordeum v. var. vulgare, Triticum dicoccum
Mixed herbs	47/17	Galium type, Potentilla, Rhinanthus, Rumex acetosa, Trifolium sp., Viola	Achillea type, Alchemilla, Allium, Apiaceae, Aster type, Brassicaceae, Caltha type, Campanula type, Cannabis type, Compositae sf cichorioidae, Cyperaceae, Dianthus type, Fabaceae, Filipendula, Geranium, Hypericum, Jasione, Labiatae, Liliaceae, Lotus, Lychnis type, Melampyrum, Menyanthes, Narthesium ossifragum, Onagraceae, Ononis type, Plantago maritima, Plantago sp., Polygala, Rosaceae, Scleranthus, Scrophularia type, Sedum, Sparganium type, Stachys type, Succisa, Thalictrum, Trientalis, Trifolium pratense type, Urtica type, Valeriana	Carex, Cornus suecica, Juncus, Hieracium, Lamiaceae, Lapsana communis, Luzula, Rumex acetosella, Scirpus, Trifolium sp., Vicia
Total number	82/47	18	64	29

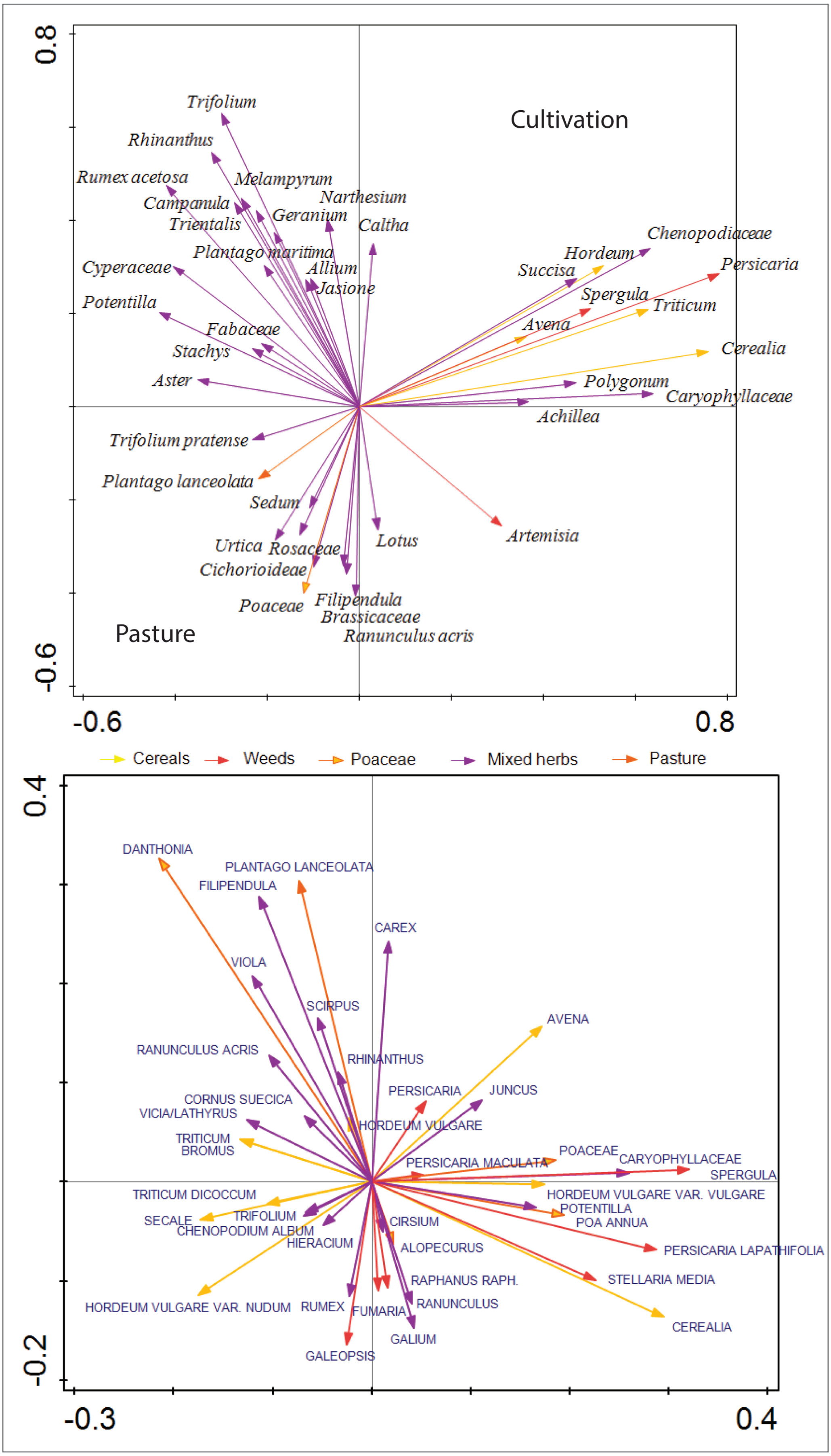
5\.

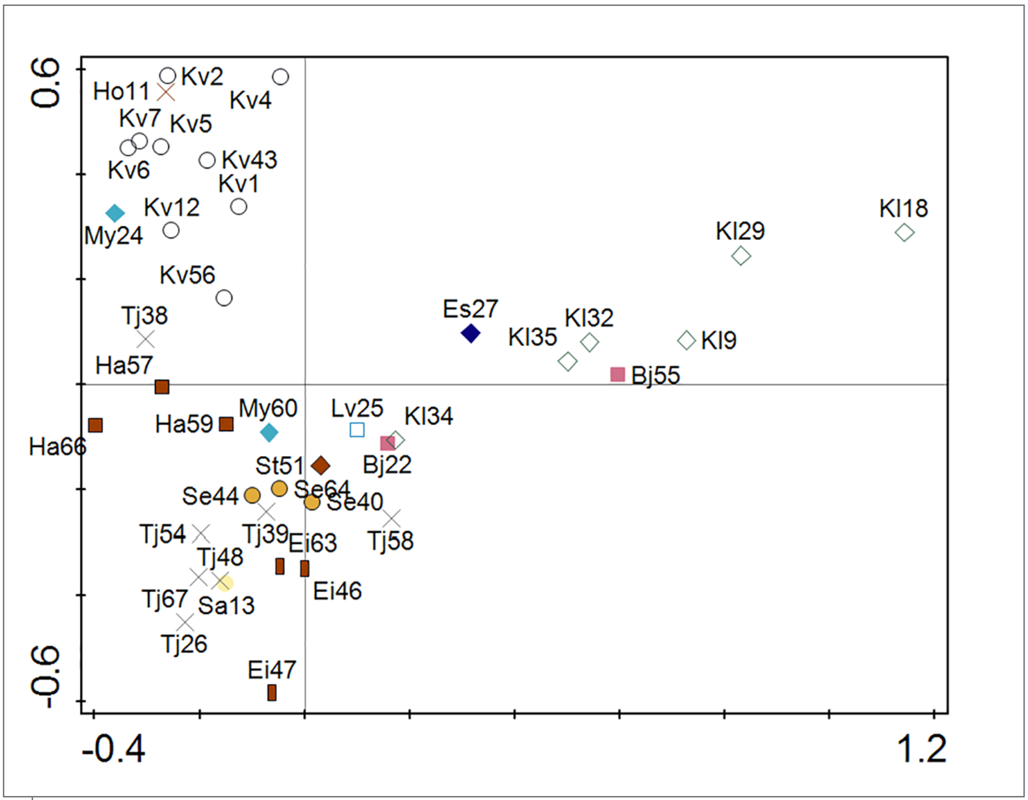
Identified pollen and charred macrofossil taxa from 68 buried cultivation layers at 19 sites in Rogaland, SW Norway.

(TJ54). The pollen records obtain the best representation regarding indicators of arable fields as well as pasture, and display a high inter-relationship between the dominant groups of trees, grasses, and dwarf shrubs (figures 3, 4).

From a total of 82 identified pollen taxa and 47 macrofossil taxa, only 18 of them correspond in such a way that the same mother plant taxon is recognized (figure 5). Pollen presents a higher taxa diversity, especially for trees and mixed herbs. The lack of *Calluna* macrofossils may be due to the small size of *Calluna* seeds and leaves, and can be compensated for methodologically. Several of the observed diaspore types identified at genus level are represented by only one or two species that may be relevant for the local or regional flora.

The structure of the datasets with respect to response model, is tested by DCA and shows a linear response for pollen (1.49 SD unit) and unimodal for macrofossils (6 SD units reduced to 4.29 when the outlier *Cornus suecica* is removed). A PCA of all pollen taxa with supplementary spore taxa maintains the open-forested gradient described in Fredh et al. (2018) of which the sites Kvåle and Kleppevarden account for the main variation along the first and second axis, respectively. The projected spore taxa reflect similar main gradients, with *Gymnocarpium* positively correlated with *Betula* and *Calluna*; Polypodiaceae (ferns unspecified) with *Corylus* and *Alnus*; while *Sphagnum* and *Polypodium vulgare* are positively correlated with arable field taxa.


Cultivation
Pasture
Trifolium
Rhinanthus
Rumex acetosa
Melampyrum
Campanula
Narthesium
Trientalis
Geranium
Caltha
Plantago maritima
Allium
Jasione
Cyperaceae
Potentilla
Fabaceae
Stachys
Aster
Chenopodiaceae
Hordeum
Succisa
Persicaria
Spergula
Triticum
Avena
Cerealia
Polygonum
Caryophyllaceae
Achillea
Trifolium pratense
Plantago lanceolata
Sedum
Urtica
Rosaceae
Cichorioideae
Lotus
Artemisia
Poaceae
Filipendula
Brassicaceae
Ranunculus acris
0.8
-0.6
-0.6
0.8
Cereals
Weeds
Poaceae
Mixed herbs
Pasture
0.4
-0.2
-0.3
0.4
DANTHONIA
PLANTAGO LANCEOLATA
FILIPENDULA
CAREX
VIOLA
SCIRPUS
AVENA
RANUNCULUS ACRIS
RHINANTHUS
PERSICARIA
JUNCUS
CORNUS SUECICA
VICIA/LATHYRUS
HORDEUM VULGARE
TRITICUM
BROMUS
POACEAE
CARYOPHYLLACEAE
PERSICARIA MACULATA
SPERGULA
TRITICUM DICOCCUM
HORDEUM VULGARE VAR. VULGARE
POTENTILLA
POA ANNUA
SECALE
TRIFOLIUM
CHENOPODIUM ALBUM
CIRSIUM
HIERACIUM
ALOPECURUS
PERSICARIA LAPATHIFOLIA
STELLARIA MEDIA
RAPHANUS RAPH.
HORDEUM VULGARE VAR. NUDUM
RUMEX
FUMARIA
RANUNCULUS
CEREALIA
GALIUM
GALEOPSIS



6. (Previous page and this page)
Presence-absence of herb pollen taxa are treated as response variables (above) in a PCA ordination with herb macrofossil taxa as supplementary variables (below) and classified according to taxa groups (see figure 4 for legend). Explained variation by the first two axes is 14%, while herb macrofossils account for 65,8% of the total variation. The 40 best fitting species are displayed.

The difference in abundance measure and response model justifies presence-absence in statistical correlation. The main unconstrained gradient of pollen positively separates sites strongly correlated with cereals and weeds (Kleppevarden, Bjorhaug, Espeland) from those related to mixed herbs and pasture (mainly Hana and Tjora) (figure 6). The variation along the second axis ranges from sites correlated with grassland taxa like Poaceae and *Ranunculus acris* (Eik, Tjora, Sakkastad) to *Caltha* and *Narthesium* from moist habitats, and natural meadow and forest communities (Kvåle, Hove). The main gradient of macrofossils separates sites correlated with the presence of *Spergula*, Caryophyllaceae and *Hordeum vulgare* var. *vulgare* (Bjorhaug, Kleppevarden) from sites with *Triticum dicoccum* and *Secale* (Tjora, Hana). The second axis separates sites with ruderal taxa like *Galeopsis* (Eik) from those with sedges like *Carex* and *Scirpus*. The sites Kvåle and Hove are strongly related to *Plantago lanceolata*, *Danthonia* and *Filipendula*, while sites with *Avena* and *Hordeum vulgare* var. *nudum* are negatively correlated (Espeland and Tjora).

When age and sites are used as explanatory variables in RDA ordinations, the variation explained by the significant explanatory variables is 35% for pollen and

19% for macrofossils, giving room for a large fraction of unexplained variation. A weak significant correlation is observed between arable herbs, Kleppevarden and RIA. Hove and Tjora are most strongly correlated with grasses and mixed herb taxa like *Cerastium*, Brassicaceae, *Artemisia* and *Ranunculus acris* possibly originating from meadows and arable land, related to LBA V and MIG. Among macrofossils *Plantago lanceolata* and sedges are correlated with MED and weakly with Kvåle. A variety of herbs associated with disturbed sediments, like *Galeopsis*, *Stellaria media* and *Fumaria* are correlated with Sømme IV and PRIA.

An RDA of herb pollen with macrofossil groups as explanatory variables rendered non-significant axes. No macrofossil groups tested significant when the effect of age and site was partialled out as covariates. Hence, pollen and macrofossils do not reflect a similar vegetation signal.

Discussion

Pollen and macrofossils jointly support the identification of cultivation layers on site, since diaspores from cereals or weeds are present in nearly all layers. The advantage of applying both parameters on reworked soil types is demonstrated by the increase in identifiable plant taxa. The higher diversity of pollen taxa among trees and mixed herbs (and spore plants) is a strength of the pollen records, while identification to a lower taxonomic level, species and below, is the advantage of the macrofossils. The higher differentiation into cereal types plus annual and perennial weeds reveal ecological information about agricultural management and field systems that is not met by pollen analysis (figure 6), which is in line with Prøsch-Danielsen and Soltvedt (2011).

The variation in the tree pollen record may include a signal of pioneer cultivation, i.e. fields established in pristine woodland (figure 4). The presence of pasture herbs in the pollen record is constant during the entire time span and indicates combined pastoral farming and cultivation as the main farming practice. A mowing signal may be concealed within the mixed herb group.

Pollen and spores from heathland and mire are most likely derived from peat applied to the field and/or from manure rather than having been wind-dispersed from the surrounding vegetation. If the field has been burned as part of management practice, charred macrofossils of these species might be expected. The fact that seeds from edible shrub plants (raspberries, blackberries, elder, bog myrtle) dominate, supports the idea that they are brought to the field with ashes from the household. Dwarf shrubs (*Empetrum*, *Arctostaphylos uva-ursi*), are however present from the Merovingian and Viking Age onwards, coinciding with the increase in *Calluna* dominated dwarf shrub pollen, and may reflect a change in management.

The residual, unexplained variation of ordinations is generally high, partly caused by statistical noise due to many zero occurrences in response data. Adding more environmental metadata to the analyses may, however, increase the analytic outcome. Both methods possess the potential for extracting more information out of the samples, like observations of fungal spores, abnormal pollen affected by fire and corrosion, uncharred diaspores included in the macrofossil record, and size and morphology of charcoal micro- and macroparticles.

Conclusion

There is a more evident vegetation signal in the pollen data, while the floristic variation related to cultivation is stronger among macrofossils. However, the cultivation signal in pollen is strong, and likely to be reflected in nearby wetlands. The ability to identify cereal and weed species through macrofossil analysis enables a more subtle interpretation of a cultivation regime, while the wider ecological representation among pollen and spore taxa helps elucidate the importance of added animal dung or peat for enriching the fields. Both methods help display different aspects of cultivation management and cannot replace each other in a study concerning past cultivation practices. Charred macrofossils are probably derived from household ashes; therefore, interpretation would benefit from comparisons with material from houses and associated structures.

Acknowledgements

This paper is a follow-up of the research initiated and financed by the UiS Research Programme »Prehistoric Farming at the North European fringe – Interdisciplinary Aspects« (2013–2015) and linked to the Agrarian Network, financed by the Norwegian Research Council (NRC). The inspiring discussions with colleagues are very much appreciated, as well as the comments by an anonymous reviewer.

Literature

Bjørdal, E., Mikkelsen, K., Mooney, D.E., Lechterbeck, J., Gebremariam, K.E. & Hollund, H. 2019. Arkeologisk undersøkelse av aktivitets- og bosetningsområde ID 177683 fra stein-, bronse- og jernalder, med dyrkingslag,husrester og kokegroper. Sakkastad gnr 36, bnr. 4, Haugesund kommune. *Report 2019/18, Museum of Archaeology*, University of Stavanger.

Bronk Ramsey, C. 2017. Methods for summarizing radiocarbon data sets. Radiocarbon 59: 1809–1833. DOI: https://doi.org/10.1017/RDC.2017.108.

Børsheim, R.L., Soltvedt, E.C. 2002. Gausel – utgravningene 1997–2000. *AmS-Varia* 39: 1–294

Dimbleby, G.W. 1985. *The palynology of archaeological sites*. Academic Press Inc. (London): 1–176.

Fredh, E.D. & Mooney, D.E. 2020. Undersøkelse av dyrkingslag og steinbelte fra jernalder på Espeland. Gnr. 25, bnr 12, Sandnes kommune. *Report 2020/10, Museum of Archaeology*, University of Stavanger.

Fredh, E. D. & Westling, S. 2014. Naturvitenskapelige undersøkelser på Bjorhaug. Bjorhaug gnr. 25 bnr. 2, 18 og Bøhagen gnr. 26 bnr. 9, 14, 130 m.fl., Hå kommune, Rogaland. *Report 2014/25 Museum of Archaeology*, University of Stavanger.

Fredh, E.D., Prøsch-Danielsen, L. & Jensen, C.E. 2018. A synthesis of pollen composition in prehistoric cultivation layers in Southwestern Norway. *Environmental Archaeology*, DOI: 10.1080/14614103.2018.1536499.

Fyllingen, H., Lechterbeck, J. & Mooney, D. 2019. Arkeologiske undersøkelser av bosetningsspor og dyrkingslag fra eldre og yngre jernalder på Leigvam gnr 13, Sandnes kommune, Rogaland. *Report 2019/16 Museum of Archaeology*, University of Stavanger.

Halvorsen, L.S. & Hjelle, K.L. 2017. Prehistoric agriculture in western Norway – evidence for shifting and permanent cultivation based on botanical investigations from archaeological sites. *J. Archaeol.l Sci. Reports* 13: 682–696.

Hjelle, K.L., Solem, T., Halvorsen, L.S. & Åstveit, L.I. 2012. Human impact and landscape utilization from the Mesolithic to medieval time traced by high spatial resolution pollen analysis and numerical methods. *J. Archaeol. Sci.* 39: 1368–1379.

Husvegg, J.R., Ahlqvist, J. & Fredh, E. D. 2015. Arkeologisk og naturvitenskapelig undersøkelse av dyrkingslag og kokegroper på Kleppevarden vest gnr. 1, bnr. 6, Klepp kommune, Rogaland. *Report 2015/19 Museum of Archaeology*, University of Stavanger.

Jensen, C.E. 2020. Tracing pioneer agriculture in northern Norway. *Advances in Archaeobotany*, Barkhuis Publishing, Netherlands.

Jensen, C. & Arntzen J.E. 2016. A Late Bronze Age sheep farm north of the Arctic Circle? In: Iversen F, Petersson H (eds.): *Agrarian living in the North BC 1800–1000 AD. Studies in rural settlements and farming in Norway*. Portal, Kristiansand, Norway.

Jensen, C.E., Ahlqvist, J. & Fredh, E. D. 2015. Arkeologisk og naturvitenskapelig undersøkelse av forhistoriske åkerlag på Eik, g.nr.67, b.nr.2, Sjernarøyene, Finnøy k. *Report 2015/11, Museum of Archaeology*, University of Stavanger.

Jensen, C.E. & Soltvedt, E.C. 2011. Makrofossil- og pollenanalyser fra røysfelt på Mæland. Mæland gnr. 68, bnr. 6, Hå kommune. *Report 2011/32 Museum of Archaeology*, University of Stavanger.

Lempiäinen-Avci, M. & Tjemsland, A.E. 2017. Rapport fra undersøkelser av dyrkningslag fra bronsealder på Hana, ID 171179. Hana gnr 38 bnr 48, Sandnes kommune, Rogaland. *Report 2017/5 Museum of Archaeology*, University of Stavanger.

Meling, T., Jensen, C. E. & Soltvedt, E. C. 2020. Arkeologiske og naturvitenskaplige undersøkelser av landbruks- og bosetningsspor fra seinneolitikum til middelalder, samt metallhåndverk fra vikingtid (id 150770, id 150765, id 150766) på Sømme (Sømme IV). Sømme gnr. 15, bnr. 5 m. fl. i Sola kommune, Rogaland fylke. *Report 2020/16 Museum of Archaeology*, University of Stavanger.

Overland, A. 2012. Naturvitenskapelige undersøkelser av dyrkingslag på Myklebust. Myklebust gnr. 3, Sola kommune. *Report 2012/15 Museum of Archaeology*, University of Stavanger.

Overland, A,, Hjelle, K.L. 2013. Pollen analysis in the context of clearance cairns from boreal forests – a reflection of past cultivation and pastoral farming. *J. Archaeol. Sci*. 40 (2):1020–1041 https://doi.org/10.1016/j.jas.2012.08.031.

Prøsch-Danielsen, L. & Soltvedt, E.C. 2011. From saddle to rotary hand querns in southwestern Norway and the corresponding crop plant assemblages. *Acta Archaeologica* 82: 129–162.

Reimer, P.J., Bard, E., Bayliss, A., Beck, J.W., Blackwell, P.G., Bronk Ramsey, C., Grootes, P. M., Guilderson, T.P., Haflidason, H., Hajdas, I., HattŽ, C., Heaton, T.J., Hoffmann, D.L., Hogg, A.G., Hughen, K.A., Kaiser, K.F., Kromer, B., Manning, S.W., Niu, M., Reimer, R. W., Richards, D.A., Scott, E.M., Southon, J.R., Staff, R.A., Turney, C.S.M., & van der Plicht, J. (2013). IntCal13 and Marine13 Radiocarbon Age Calibration Curves 0–50,000 Years cal BP. *Radiocarbon*, 55(4).

Sandvik, P.U. 1999. Analysar av plantemakrofossilar i jordprøver frå Sørbøtunet, Skei gnr. 43 og Sørbø gnr. 45, bnr. 1 og 2–4, Sandnes kommune, Rogaland. *Report 1999/2 Museum of Archaeology*, University of Stavanger.

Sandvik, P.U. 2018. Myklebust gnr. 3 Sola k., Rogaland. Analysar av makroskopiske subfossil. *Report 2018/11, Museum of Archaeology*, University of Stavanger.

Sjögren, P. & Arntzen, J. 2013. Agricultural practices in Arctic Norway during the first millennium B.C. *Vegetation History and Archaeobotany* 22,1–15.

Solem, T, 2001. Pollenanalytiske undersøkelser av prøver fra jordprofiler, ardspor og gravhauger fra utgravningsfeltet "Gausel Nord", Gausel gnr. 14, Stavanger kommune, Rogaland fylke kommune. *Report 2001/9 Museum of Archaeology*, University of Stavanger.

Soltvedt, E.C. & Enevold, R. 2009. Naturvitenskapelige undersøkelser i spor etter jernalderbebyggelsen på Tastarustå. Øvre Tasta gnr. 28, bnr. 54, 63, 11 og 26, Stavanger kommune. Report 2009/29 Museum of Archaeology, University of Stavanger.

Soltvedt, E.C. & Jensen, C.E. 2011. Makrosubfossil – og pollenanalyser fra forhistoriske åkerlag, hustomter og graver på Tjora. Tjora gnr. 10 bnr. 5, 17 og 19, Sola kommune. *Report 2011/24 Museum of Archaeology*, University of Stavanger.

Soltvedt, E.C. & Tjemsland, A.E. 2017. Botaniske undersøkelser av dyrkingslag på tomt Ørpetveitveien 8, Fedjedalen gnr.3, bnr. 78, Haugesund kommune, Rogaland. *Report 2017/17 Museum of Archaeology*, University of Stavanger.

Soltvedt, E.C., Løken, T., Prøsch-Danielsen, L., Børsheim ,R.L. & Oma, K. 2007. Bøndene på Kvålehodlene. Boplass-, jordbruks- og landskapsutvikling gjennom 6000 år på Jæren, SV Norge. AmS-Varia 47 Museum of Archaeology, University of Stavanger.

Ter Braak, C.J.F. & Smilauer, P. 2012. CANOCO reference manual and users guide software for ordination (Version 5.0). Microcomputer Power, Ithaca, NY, USA.

Vorren, K.-D., Nilssen, E. & Mørkved, B. 1990. Age and agricultural history of the "staðir" farms of North and Central Norway. *Norwegian Journal of Geography* 44: 79–102.

Westling, S. & Fredh, E.D. 2014. Naturvitenskapelige undersøkelser på Grødaland Hobberstad, gnr. 40, bnr. 7, Hå k. Rogaland. *Report 2014/3 Museum of Archaeology*, University of Stavanger.

Westling, S. & Jensen, C.E. 2020. Indications of rye (Secale cereale) cultivation from 7th Century southwestern Norway. In Vanhanen, S. & Lagerås, P. (eds.) Archaeobotanical studies of past plant cultivation in northern Europe. *Advances in Archaeobotany* 5: 83–99., Barkhuis Publishing, Netherlands.

Westling, S. & Overland, A. 2012. Naturvitenskapelige undersøkelser på Kvia-Motland. Kvia gnr. 19/13 og Motland gnr. 20/3, Hå k., Rogaland. *Report 2012/3 Museum of Archaeology*, University of Stavanger.