RESEARCH PAPER TITLE

Farming and foraging in Neolithic Ireland: an archaeobotanical perspective

AUTHORS' NAMES AND CONTACT DETAILS

Meriel McClatchie[1, 2], Amy Bogaard[3], Susan Colledge[4], Nicki J. Whitehouse[2, 5], Rick J. Schulting[3], Philip Barratt[2, 5] and T. Rowan McLaughlin[2]

[1] School of Archaeology, University College Dublin, Newman Building, Belfield, Dublin 4, Republic of Ireland, meriel.mcclatchie@gmail.com;

[2] School of Geography, Archaeology and Palaeoecology, Queen's University Belfast, Belfast BT7 1NN, Northern Ireland;

[3] School of Archaeology, University of Oxford, 36 Beaumont St, Oxford OX1 2PG, UK;

[4] Institute of Archaeology, University College London, 31-34 Gordon Square, London WC1H 0PY, UK;

[5] School of Geography, Earth and Environmental Sciences, Plymouth University, Drake Circus, Plymouth PL4 8AA, UK

TEXT

Introduction

The introduction of agriculture is arguably *the* defining characteristic of the Neolithic period in Europe. Ireland is on the margins of Europe, located at its north-western edge, and agriculture made its way to this region during the fourth millennium cal BC. The main crops in Neolithic Ireland (4000-2500 cal BC) were wheat (*Triticum* spp.) and barley (*Hordeum* spp.), but we know little about their relative importance, the intensity of agricultural activity, or how crops varied across space and time. International narratives on prehistoric agriculture rarely mention the Irish evidence, except as an adjunct to British research, despite indications of divergence between the two regions (Cooney 2000; Bradley 2007). It is not clear if early agriculture in Ireland reflects primarily special or symbolic consumption in 'ritual' contexts

(Edmonds 1999; Thomas 2003, 2008), or if crops provided a major component of daily subsistence, as has been proposed for parts of central Europe (Monk 2000; Jones and Rowley-Conwy 2007). This paper will reveal new findings from a major study of plant macro-remains from Neolithic Ireland, investigating the variety of crops recorded at different times and locations, and exploring what this tells us more broadly about Neolithic society.

Arable agriculture in Neolithic Ireland: the story so far

Current perspectives on the arrival of agriculture into Ireland are based upon a limited published archaeobotanical dataset, consisting of 10 sites at most (Monk 2000; Colledge et al. 2005; Jones and Rowley-Conwy 2007). New archaeobotanical data have, however, recently become available as a result of the many excavations of Irish Neolithic sites over the past two decades (Cooney 1999; Grogan 2002; Smyth 2006, 2014). These excavations were often associated with large-scale infrastructural developments, and the excavation reports are in most cases completed but unpublished, forming part of the so-called 'grey literature'. A pilot study of published and unpublished data was undertaken in 2007 (McClatchie, accepted), revealing that a lack of published data was masking both the scale and variety of plant macro-remains from Neolithic Ireland.

A more comprehensive review was required to better understand this recently excavated evidence. A major research project, "Cultivating Societies: Assessing the Evidence for Agriculture in Neolithic Ireland", was established in 2008 to examine the nature, timing and extent of agricultural activity during this period (Whitehouse et al. 2010, 2014). The project provided a timely opportunity to collate and analyse different strands of archaeological and environmental evidence, with a particular focus on plant macro-remains, pollen and 14C data. This paper presents the results of an analysis of the plant macro-remains data, with a focus on contexts in which cereals were recorded, and contrasting patterns from earlier and later Neolithic periods. Results of further archaeobotanical work are provided elsewhere, including comparison of data from Ireland and Europe, and analysis of arable weed data to explore management of cultivation plots (McClatchie et al. 2014).

Methods of analysis

Archaeobotanical data were collated from 52 excavated sites (Figure 1), around two-thirds of which were unpublished at the time of collation. Tracking down and subsequent verification of data was a very lengthy process, but this approach resulted in the creation of a comprehensive and robust dataset. In addition to these 52 sites, cereals were recorded at a further 17 Neolithic sites (Figure 1), but final excavation reports from these sites were incomplete, and they were therefore excluded from analyses. A small number of sites also produced evidence for Neolithic ceramic vessels that displayed seed impressions (McClatchie et al. 2014).

As well as collating available radiocarbon dates, the "Cultivating Societies" project undertook an extensive, targeted AMS 14C dating programme, which provided 187 additional dates to further refine site chronologies (Whitehouse et al. 2014). The dates were obtained from short-lived species (mainly cereal grains and hazelnut shell, *Corylus avellana* L.). Results from Bayesian analysis of the 14C dates were used, where possible, to assign sites to the following chronological categories: Early Neolithic (EN I & II), Middle Neolithic (MN I & II) and Late Neolithic (LN) (Table 1; Whitehouse et al. 2014; Schulting et al. in preparation). For the purposes of this analysis, MN II and LN sites were combined due to the small number of sites available (five MN II, four LN and two MN II/LN). Sites where calibrated date ranges spanned different periods within the Neolithic were assigned to a generic Neolithic category (NEO). Summed radiocarbon calibrations were used to investigate the occurrence of dated cereals across time and space. The technique involves the arithmetic addition of the calibrated probability mass functions for a set of radiocarbon dates.

Category and chronology of sites

Plant macro-remains data were available from a total of 437 samples from 390 contexts at 52 sites, consisting of 28 EN II sites, 10 MN I sites, 11 MN II-LN sites and three NEO sites (Table 2; Supplementary File 1). The new 14C dating programme revealed that several sites contained later material that had become incorporated into Neolithic deposits (Supplementary File 1; Whitehouse et al. 2014). The presence of intrusive, often unexpected, later material underlines the importance of obtaining multiple 14C determinations when attempting to understand the chronology of an individual Neolithic site. The vast majority of plant remains were preserved by

charring. Waterlogged remains were recorded at just three sites: Clowanstown burnt mounds, turf layers at Newgrange passage tomb and ditch fills at Rathdooney Beg barrow.

Archaeobotanical data from a total of 28 EN II sites were examined (Table 2), the majority of which were rectangular structures/houses (17/28 sites), both single and multiple. Rectangular structures were, however, just one element of the settlement landscape. Other EN II sites consisted of non-rectangular structures and possible structures, pit complexes, burnt mounds, a causewayed enclosure and a barrow. Pit and post-hole complexes, some of which are likely to represent the fragmentary remains of structures, dominated the 10 MN I sites examined (Table 2). MN I plant remains were also recorded from a passage tomb. Eleven sites were dated to the MN II-LN period (Table 2), including pit/post-hole complexes, a possible round-house, a circular structure and two passage tombs. Three sites were dated to the NEO period, as they contained remains that could not be attributed to any specific sub-period (Table 2).

Plant categories recorded

A variety of different plant groups was recorded at the 52 examined sites. Hazelnut shell remains were most common, being present at 87% of sites (45/52), closely followed by cereal remains, which were recorded at 77% (40/52). Fruit remains were present at approximately one-fifth of sites (19%; 10/52). Crab-apple (*Malus sylvestris* L.) and bramble (*Rubus* spp.) dominated the fruit remains, with occasional evidence for elder (*Sambucus nigra* L.). Other wild plant remains were found at almost half of examined sites (46%; 24/52) - many of these remains appear to represent inadvertent harvesting of arable weeds growing alongside the cereals. Flax (*Linum usitatissiumum* L.) remains were relatively rare, being recorded at only 4% of sites (2/52; including 14C-dated flax). Fabaceae seeds (pea family) were present at 2% of sites (1/52), but it is likely that these represent wild plants rather than cultivated legumes. Although pea (*Pisum sativum* L.) remains were found in a Neolithic deposit at Castletown Tara, 14C dating of this material as part of the project revealed that they were medieval (UBA-14682: 374±28 BP, cal AD 1447-1631).

Analysis of the types of plants recorded during different time periods revealed a number of interesting patterns (Figure 2). Cereals were present at 86% (24/28) and 90% (9/10) of EN II and MN I sites, respectively. This contrasts sharply with evidence

from MN II-LN sites, where cereals were recorded at only 36% of sites (4/11; two MN II sites and two LN sites). While the difference seems striking, formal statistical testing is not straightforward because insufficient information is available on the number and volume of deposits sampled at each site, and it is possible that the pattern is influenced by differences in sampling strategies. Effects on the archaeological record of variable sampling strategies are discussed further below. Summed radiocarbon calibrations of directly dated cereal remains (Figure 3; Supplementary File 2) indicate that agriculture appeared simultaneously in all areas of the island during the EN II period. None of the MN II-LN cereals have been directly dated, and it is possible that at least some may reflect later activity at Neolithic sites.

Hazelnut shell remains were found at a slightly larger number of EN II and MN I sites when compared with cereals (93% or 26/28 EN II sites; 90% or 9/10 MN I sites). During the MN II-LN period, there was also a decrease in the number of sites where nutshell remains were recorded (73% or 8/11 sites), although the decrease was not as marked as the decrease in cereals. Fruit remains were recorded at just under one-fifth of EN II sites (5/28), absent from MN I sites, and present at just over one-third of MN II-LN sites (4/11). Remains of other wild plants were found at around half of all EN II and MN II-LN sites (14/28, 6/11), but at just under one-third of MN I sites (3/10). Flax was present at a small number of EN II sites (2/28), but absent from later deposits. After data collation for this project was completed, a further MN I example of 14C dated flax was reported at Tullahedy, Co. Tipperary (McClatchie 2011).

Many of the cereal remains from EN II sites were associated with rectangular structures. Cereals were most often found in the slot-trenches of these rectangular structures, but were also present in associated post-holes, post-pits, stake-holes and pits. Almost all MN I sites contained cereal remains, with most of the remains recovered from pit/post-hole complexes. In contrast, most MN II-LN sites did not contain cereal remains. Where cereals were recorded, they were associated only with structures/possible structures. Cereals were absent from MN II-LN burial sites and pit/post-hole complexes. Large cereal assemblages (more than 100 grains) were recorded at five sites (four EN II: Caherabbey Upper, Caw, Clowanstown and Tankardstown South; one NEO: Castletown Tara), with a relatively small quantity of grains present at other sites, usually between one and 25 grains (further discussed in McClatchie et al. 2014).

Cereal types present

The cereal remains consisted of wheat and barley (Figure 4). Wheat dominated at EN II sites, but barley was also recorded at just over half of these sites. Wheat again dominated at MN I sites, with barley recorded at less than one-quarter of sites. Barley was found at slightly more MN II-LN sites when compared with wheat, but this is based on a very small number of sites (four), and may not be representative of cereal preferences during this later period.

Although oat was present at eight sites, 14C dating at two sites (Monanny and Lismullin) revealed that the oat grains were later intrusions. Oat remains have, however, been radiocarbon dated to the Early Neolithic period at Balbridie in Scotland (Fairweather and Ralston 1993), indicating that not all oat remains from Neolithic deposits in northern Europe should be discounted as intrusive. Where recovered in this region, oat is unlikely to have been cultivated during the Neolithic period - the oat remains instead reflect wild oat that was a weed of wheat and barley crops (Zohary et al. 2012).

Where identifiable beyond indeterminate wheat or barley, a variety of wheat and barley types was recorded, including emmer wheat (*Triticum dicoccum* Schübl.), possible einkorn wheat (*T. monococcum* L.), naked wheat (*T. aestivum/durum/turgidum* L.), hulled barley (*Hordeum vulgare* L.) and naked barley *(H. vulgare* L. var. *nudum*) (Figure 5). Emmer wheat was the dominant cereal type during the EN II and MN I periods. There are also a small number of records of naked wheat and one record of possible einkorn wheat. It should be noted, however, that only grains from naked wheat and possible einkorn wheat were present; chaff rather than grain is a more reliable indicator of wheat species (Hillman et al. 1996). Naked barley was more commonly recorded than hulled barley during the EN II period.

Turning to MN II-LN sites, although emmer wheat and naked wheat were both present, the small number of sites dating to this period precludes determination of which wheat type was more important. In the case of naked wheat, grain rather than chaff was again recorded. Barley was present, but the type of barley was not identified.

Variety of crops present

While cereals were recorded at the majority of examined sites, most individual sites contained evidence for only one crop type (wheat, barley or flax; Figure 6). This trend was most noticeable at MN I sites, where only 11% (1/9) of sites containing crops revealed evidence for more than one crop type. By contrast, more than one crop type was recorded at more than 40% of EN II sites (10/24). It is notable that where barley was present, it was more often a component of a mixed assemblage. Flax was similarly only recorded at sites where a variety of crops was present.

It is probable that the number of samples analysed from each site has influenced the variety of crops recovered. Most sites do not have a record of the total number of samples analysed (i.e. the number of samples where plants remains were present and absent), but an assessment could be undertaken of the number of samples where plant remains were recorded. At sites where cereals were absent (Figure 7), only five or fewer samples at each site contained any type of non-wood plant macro-remains. This suggests that plant-related activities - including foraging - were not significant at these sites or, more likely, that too few samples were taken to properly reflect plant use. Conversely, a wider variety of crops was more often found at sites where plant remains were present in a larger number of samples.

Discussion

The “Cultivating Societies” project has produced the most detailed study to date of plant macro-remains from Neolithic Ireland. Data were derived from both published and unpublished sources, revealing a much larger quantity and variety of evidence than acknowledged in the published literature. The study revealed that cereals, hazelnut shells and fruits have been found at many Neolithic sites in Ireland. Emmer wheat was the most important cereal, while barley (naked and hulled) was also recorded. The presence of directly-dated flax extends the known range of crops cultivated at this time. The earliest evidence for cereals was mainly associated with EN II rectangular houses. Although these rectangular houses were relatively short-lived, being built and occupied for less than two centuries (McSparron 2008; Whittle et al. 2011; Whitehouse et al. 2014), agriculture persisted, continuing into the MN I period. There does appear to have been a significant shift in behaviour, however,

from the MN II period, when both cereals and ‘domestic’ structures become rarer in the archaeological record.

Although radiocarbon dates indicate that cereals were introduced simultaneously across the island during the EN II period (Figure 3), the geographical distribution of Irish sites containing cereals suggests an eastern and southern bias (Figures 1 and 3). It would be unwise to infer that this reflects the arrival of farming from Britain and/or France, and that early agriculture was focused on the eastern and southern seaboards. This distribution is strongly influenced by the locations of recent infrastructural developments that have undertaken large numbers of archaeological excavations, particularly road construction around urban centres. Fewer large-scale infrastructural projects have been carried out in western and northern areas of Ireland, which may explain why fewer Neolithic excavations have been undertaken there. Interestingly, the Irish pollen record reveals strong evidence for early agriculture around the north and west coasts of Ireland (Whitehouse et al. 2014). When combined, the plant macro-remains and palynological evidence indicate that farming activities were likely carried out in all seaboard areas of the island. In contrast, sites in the Irish midlands often show rather muted or unclear anthropogenic signals in their pollen records (Selby et al. 2005), suggesting limited landscape use by farming communities at this time. This corresponds with archaeological evidence, as there are relatively few EN II sites in the midlands, despite the completion of many modern infrastructural projects in the region (McLaughlin et al. in prep.).

The earliest plant macro-remains evidence for cereals in Ireland dates to the EN II period, suggesting that arable farming was not firmly established in Ireland until soon after 3750 cal BC, although there are occasional examples where the date ranges extend a little earlier (Figure 3; Supplementary File 2). The absence of cereal remains from the EN I period is significant. The earliest evidence for domesticated animal remains in Ireland has been found at Ferriter’s Cove, Co. Kerry, where cattle bone been dated to the mid-fifth millennium cal BC, thus pre-dating the Neolithic (Woodman et al. 1999). No further secure records of comparably early domesticated animal remains have been uncovered, and this evidence may represent an early phase of contact, ‘failed’ colonisation, or simply the remains of a joint of meat transported over to Ireland (Sheridan 2010; Rowley-Conwy 2011). During the EN I period, there are several examples of engagement with Neolithic practices, for example, the construction of Magheraboy causewayed enclosure, although dating of this site is potentially problematic, given how much earlier it is than similar enclosures across Britain (Whittle et al. 2011). More secure is the recent comprehensive dating

and modelling of human bone from the Poulnabrone portal tomb, placing the beginning of deposition here firmly before 3750 cal BC (Schulting 2014). It was not until the EN II period, however, that agriculture and the wider Neolithic 'package' was embraced across Ireland.

Cereals were mainly associated with EN II and MN I sites, being found at more than 85% of sites from these periods. EN II rectangular houses, MN I pit complexes and other 'domestic' features dominate the site types from which cereals were recorded. But sites that were not 'domestic' in character also contained cereal remains, such as Baltinglass passage tomb, where 14C-dated MN I cereals were recorded. Cereal usage was therefore not exclusively associated with 'domestic' activity, but incorporated into a range of activities by different communities in various locations and circumstances. Cereals were recorded in large quantities at several sites, emphasising the importance of agriculture to some communities. Even where cereals were recorded in small quantities, the significance of gaining access to this new food, and the importance of farming in developing new identities and relationships should not be underestimated.

When compared with the earlier Neolithic (EN II and MN I), cereals were present at very few MN II-LN sites (only two MN II and two LN sites), and none of the cereals from these later sites have been directly dated. Taken at face value, this implies that cereals became less important during the MN II period, and this situation may have continued into the LN period. It should be noted, however, that far fewer MN II-LN sites have been excavated, and these later sites were subject to less intensive sampling strategies. The number of features available for sampling will affect the quantity of samples that can be taken on any individual site. EN II rectangular houses often contained a wide variety of features suitable for environmental sampling. Furthermore, sites perceived to be 'domestic' in character (such as EN II houses and MN I pit complexes) were more intensively sampled to recover domestic debris, including plant food remains.

A number of European studies have highlighted an increase in the use of wild plants during the later Neolithic, for example in north-east and southern Scotland (Bishop et al. 2009), and alpine areas of central Europe (Jacomet 2007). Interestingly, extensive waterlogged preservation in the latter region has enabled recovery of a greater variety of Neolithic wild plant foods than that found in charred assemblages (College and Conolly 2014). In the case of Ireland, a slight decrease in the incidence of

hazelnut shell and an increase in fruit remains occurred during the MN II-LN period. The increase in fruit remains may reflect diversification in food strategies or perhaps an increase in suitable habitats, such as open woodlands, for fruit procurement and perhaps even promotional strategies (Brozio et al. 2014; Warren et al. 2014; Whitehouse and Kirleis 2014).

Stevens and Fuller (2012) have argued that cereals may have been largely abandoned during the later Neolithic in parts of Britain, based on the paucity of directly dated cereal remains. The picture from Ireland is somewhat more complex. There is not a clear-cut increase in gathered foods at the expense of cereals, and we cannot assume that there was a simple shift from cultivated to wild plant food strategies. Nor, from the human stable carbon and nitrogen isotope data, does there appear to be any return to the use of marine foods along the coasts at this time (Schulting 2013), which one might expect had farming comprehensively 'failed'. The pollen data for this time suggests we have a period of regeneration of woodland, perhaps at the expense of agricultural land (Whitehouse et al. 2014). However, we should not assume that pastoralism became dominant; existing records from animal bone (Schulting 2013) and lipids (Cramp et al. 2014) have yet to provide a clear indication of increased pastoral activity when compared with the Early Neolithic. In Ireland, the small quantity of later Neolithic data for any type of plant macro-remains hampers our understanding of exactly what was happening. Research into Neolithic agriculture across Europe has tended to focus on the earlier Neolithic, unearthing evidence for crops grown by the 'first farmers'. There now needs to be a greater focus on assessing later Neolithic agricultural activity, including the development of high-precision chronologies in archaeology and environmental studies to enable a multi-proxy approach towards investigating agricultural change.

Conclusions

This study represents the most comprehensive investigation to date of plant macro-remains evidence from Neolithic Ireland. Cereals were present at many sites during the earlier Neolithic, sometimes in large quantities. Emmer wheat was the dominant crop, but barley was also recorded at a large number of sites. Flax was a further component of early agriculture in Ireland, but cultivated legumes were not. Cereals were recorded mainly at house structures and pit complexes, but also at tombs and other 'non-domestic' locations.

The picture from later Neolithic Ireland is much less clear. Plant remains, either cultivated or wild, have been found at only a small number of sites. The rarity of cereals during the later period may reflect a decrease in the importance of arable agriculture, but a corresponding shift towards wild plants cannot be assumed. The results of this study enable Ireland to be considered in more detail when exploring the introduction and development of agriculture in Neolithic Europe, which was previously unachievable because of the unpublished nature of much of the Irish data.

ACKNOWLEDGEMENTS

The work reported here was funded by the Heritage Council, Republic of Ireland under the INSTAR programme 2008-2010 for the project *Cultivating Societies: Assessing the Evidence for Agriculture in Neolithic Ireland*, (Ref. 16682 to Whitehouse, Schulting, Bogaard and McClatchie). We would like to express our thanks to our project partners, who provided invaluable advice and assistance: Jane Bunting (University of Hull); Finbar McCormick (QUB); Finola O'Carroll (CRDS Ltd, Republic of Ireland); Alison Sheridan (National Museums Scotland); Jessica Smyth (University of Cardiff); Rónán Swan (National Roads Authority); Graeme Warren (UCD).

The following archaeologists, archaeobotanists and organisations are thanked for discussions, and providing access to Neolithic data and plant remains: ACS Ltd; ADS Ltd; Aegis Archaeology Ltd; AML Archaeology Ltd; Arthur ApSimon; Centre for Archaeological Fieldwork, QUB; James Conolly, Trent University; CRDS Ltd; Department of Archaeology, UCC; Catherine Dunne; Eachtra Archaeological Projects Ltd; Allan Hall, University of York; Rubicon Heritage Ltd; IAC Ltd; Judith Carroll Network Archaeology Ltd; Kilkenny Archaeology; Susan Lyons; Margaret Gowen Ltd; NAC Ltd; National Monuments Service, Department of Arts, Heritage and the Gaeltacht; National Museum of Ireland; National Roads Authority; School of Archaeology, UCD; Stafford McLoughlin Archaeology Ltd; Stephen Shennan, UCL; TVAS Ireland Ltd; Ulster Museum; Valerie J. Keeley Ltd.

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FIGURE CAPTIONS

Figure 1: Map of Ireland showing locations of sites with recorded plant remains

Figure 2: Relative occurrence of selected plant categories at EN II, MN I and MN II-LN sites (sites n=49)

Figure 3: Cumulative ^{14}C dates from cereal grains at Irish Neolithic sites (dates n=130; East sites n=14; North sites n=7; South sites n=5; West sites n=1)

Figure 4: Presence of wheat and barley at EN II, MN I and MN II-LN sites where cereals present (sites n=37)

Figure 5: Detail of cereal types recorded at EN II, MN I and MN II-LN sites where cereals present (sites n=37)

Fig. 6: Variety of crops at each EN II, MN I and MN II-LN site where cereals present - examined by period; sites n=37)

Fig. 7: Variety of crops at each database site - examined by number of soil samples per site where plant remains present (sites n=52)

TABLES

Table 1: Chronology of Neolithic period in Ireland

Period		Date range
Early Neolithic	EN I	4000-3750 cal BC
	EN II	3750-3600 cal BC
Middle Neolithic	MN I	3600-3400 cal BC
	MN II	3400-3000 cal BC
Late Neolithic	LN	3000-2500 cal BC

Table 2: Site types from which archaeobotanical remains were recorded.

Period	No. sites	Types of sites
EN II	28	Mainly rectangular structures or 'houses' (single and multiple); also pit complexes, non-rectangular structures, causewayed enclosure, barrow, burnt mounds
MN I	10	Mainly pit and post-hole complexes; also structures, passage tomb
MN II-LN	11	Pit/post-hole complexes, structures, passage tombs
NEO	3	Cremation pit complex and settlement, possible habitation site, multiple palisade

SUPPLEMENTARY MATERIAL

Supplementary File 1

Locations, chronology and references for sites with recorded plant remains from Neolithic Ireland; also see the Cultivating Societies project website (www.chrono.qub.ac.uk/instar) to access a version of the archaeobotanical database

Supplementary File 2

Radiocarbon dates and site locations for directly dated cereal remains from Neolithic Ireland

FIGURES

Figure 1: Map of Ireland showing locations of sites with recorded plant remains

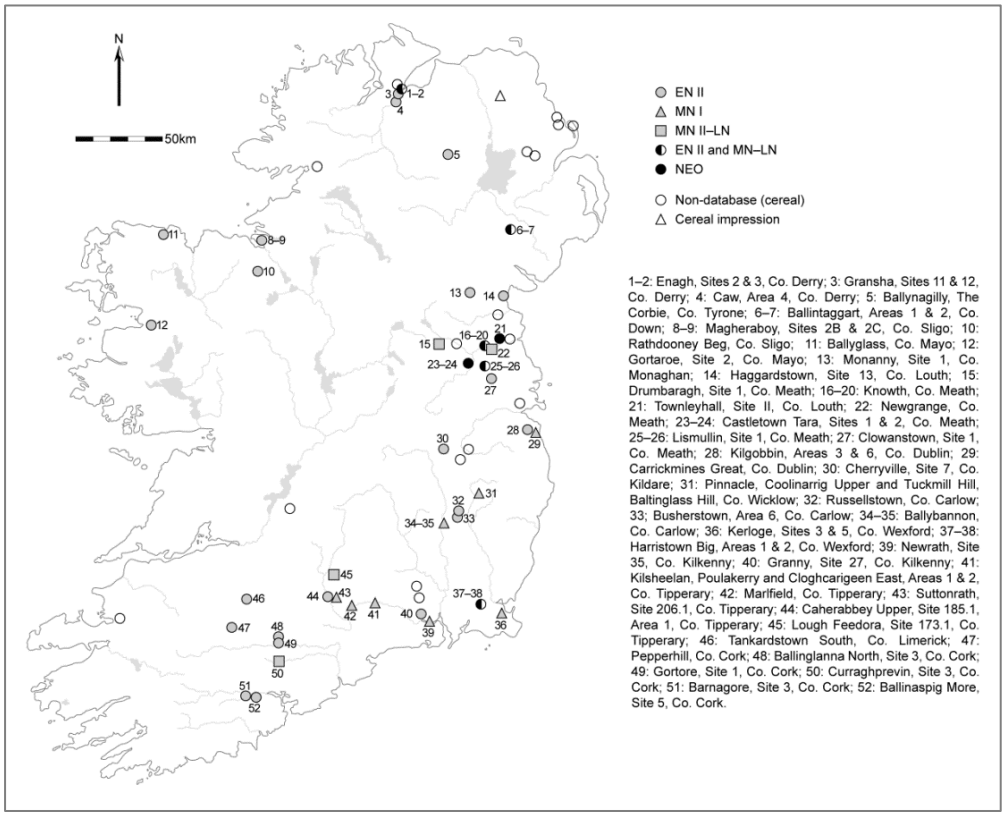

Figure 2: Relative occurrence of selected plant categories at EN II, MN I and MN II-LN sites (sites n=49)

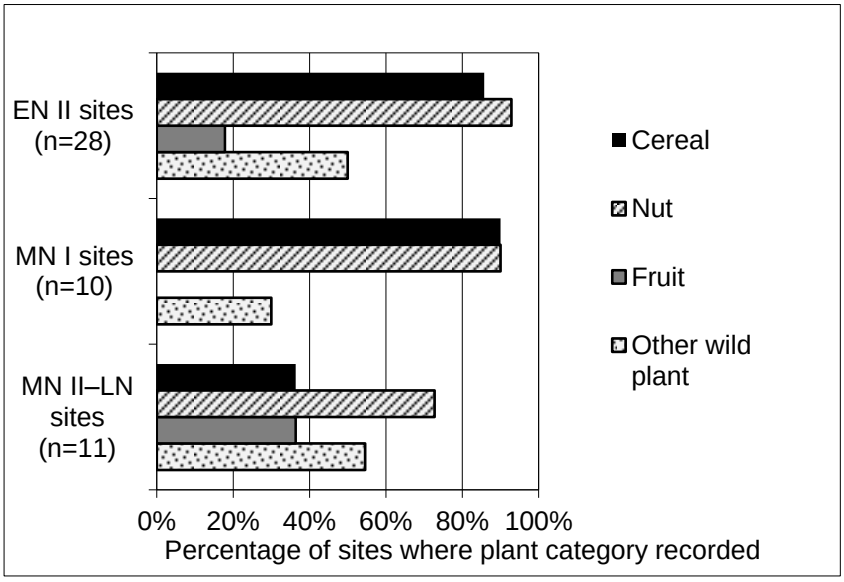

Figure 3: Cumulative ^{14}C dates from cereal grains at Irish Neolithic sites (dates n=130; East sites n=14; North sites n=7; South sites n=5; West sites n=1)

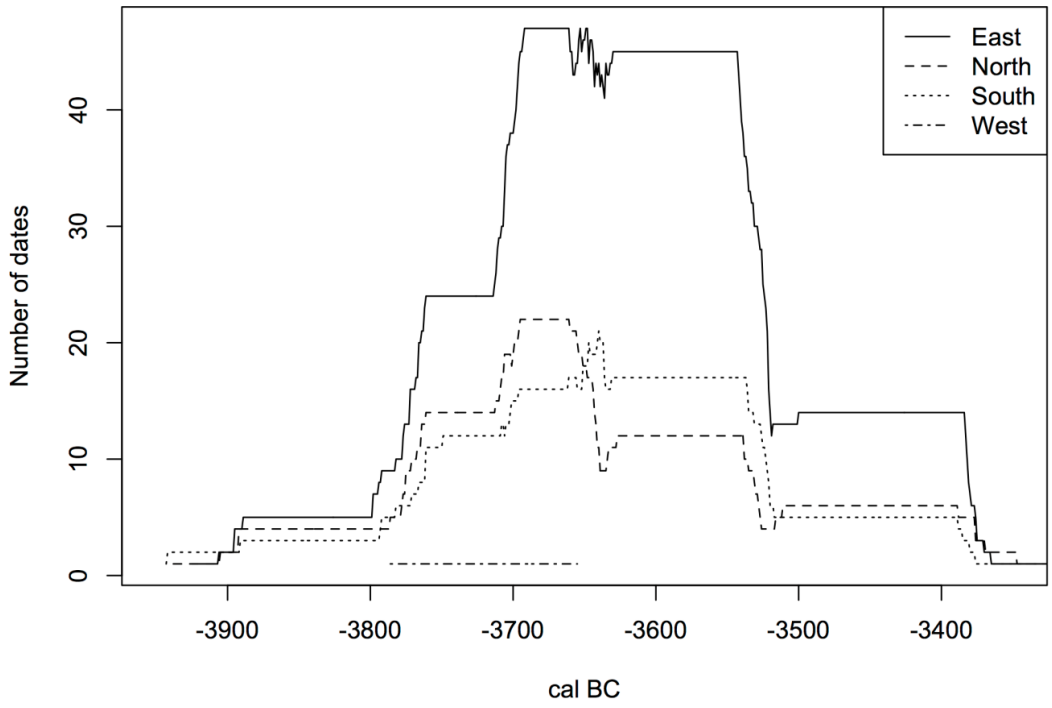

Figure 4: Presence of wheat and barley at EN II, MN I and MN II-LN sites where cereals present (sites n=37)

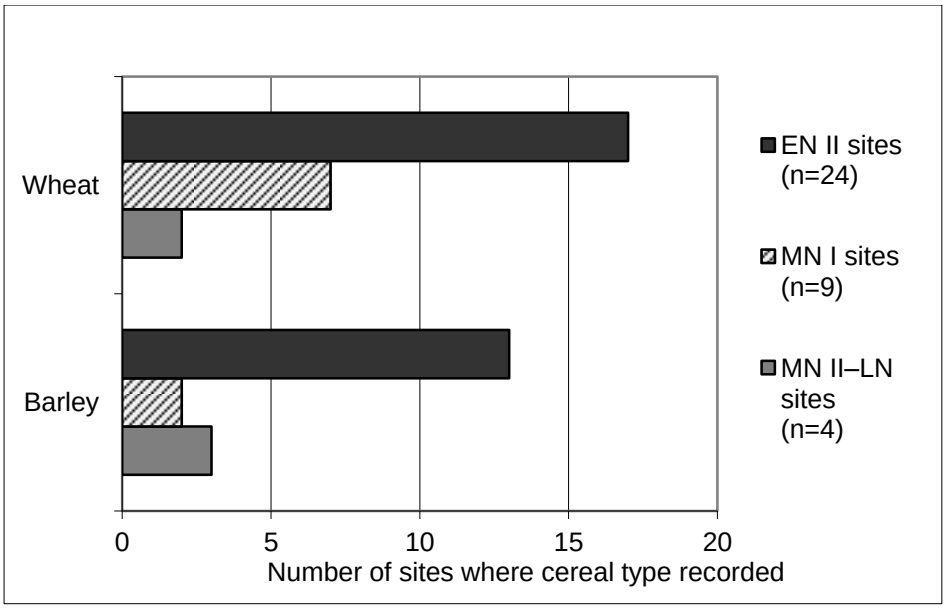

Figure 5: Detail of cereal types recorded at EN II, MN I and MN II-LN sites where cereals present (sites n=37)

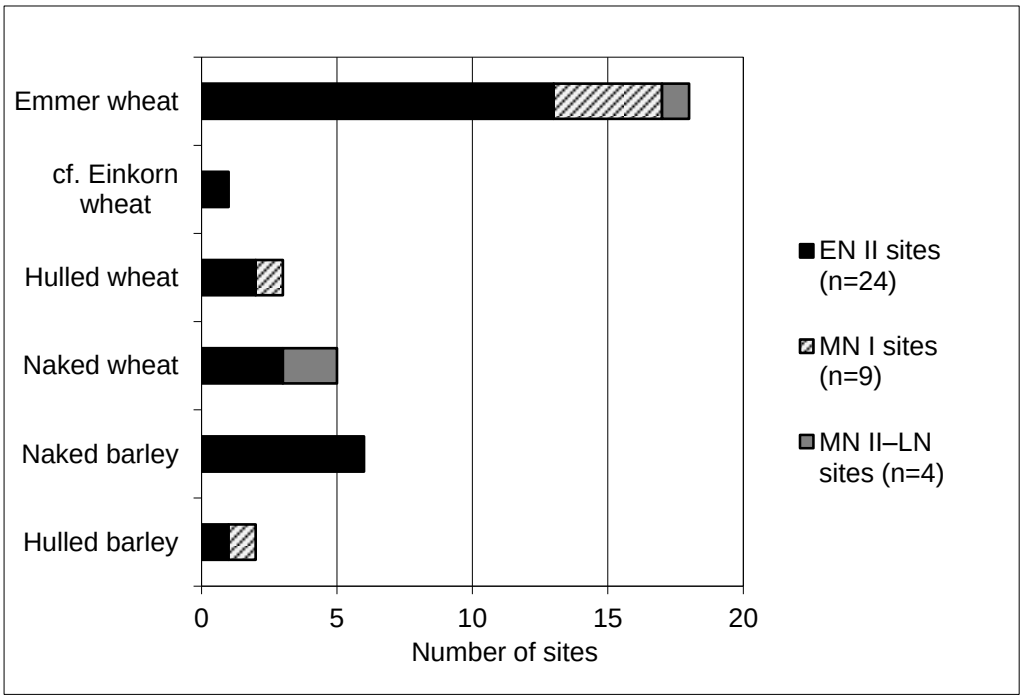

Fig. 6: Variety of crops at each EN II, MN I and MN II-LN site where cereals present - examined by period; sites n=37)

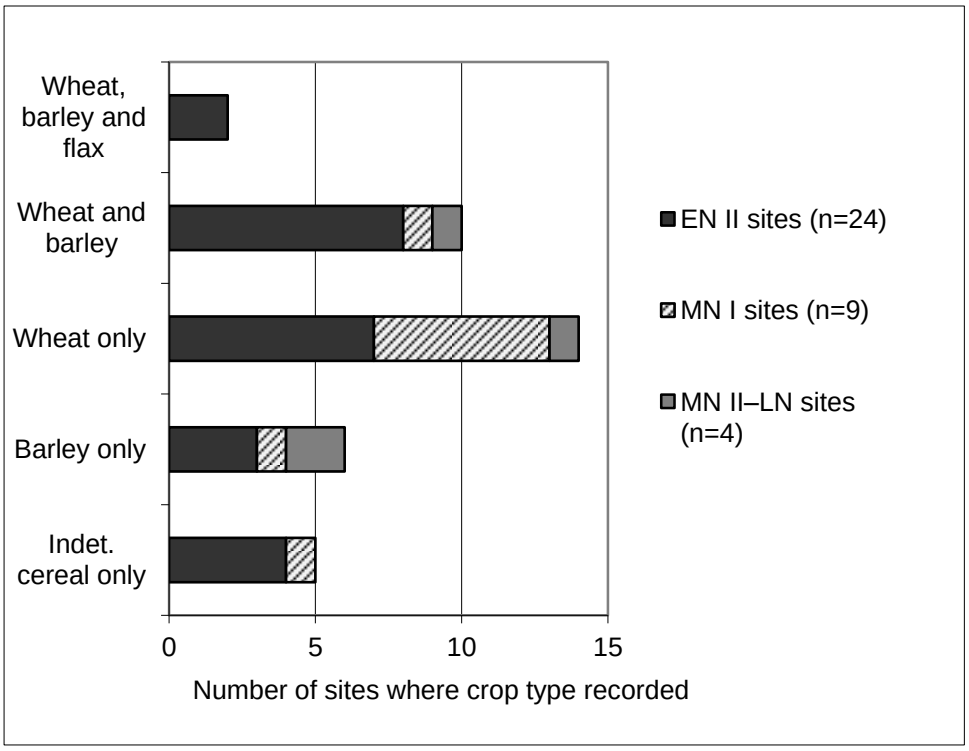

Fig. 7: Variety of crops at each database site - examined by number of soil samples per site where plant remains present (sites n=52)