TII Palaeo-environmental Sampling Guidelines

Retrieval, analysis and reporting of plant macro-remains, wood, charcoal, insects and pollen from archaeological excavations



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Contents

Cover images (l – r)

Sampling the fills of a pit at a medieval smithy, Ballykeoghan, Co. Kilkenny (James Eogan, TII).

On-site flotation of a soil sample (James Eogan, TII).

Laboratory analysis of flots from samples collected during excavation (Rubicon Heritage Services).

Executive summary

These guidelines are designed for use by archaeologists managing and undertaking archaeological excavations funded by Transport Infrastructure Ireland. Their purpose is to ensure that a standardised approach is adopted for palaeo-environmental sampling, analysis and reporting. The guidelines are intended to be used in the context of the Department of Finance-approved Standard Conditions of Engagement for Consultancy Services (Archaeological).

The key objective of these guidelines is to ensure that on-site palaeo-environmental sampling strategies and post-excavation analysis and reporting conform to the best standard and are focused on achieving high-quality and scientifically meaningful results, in the context of the Standard Conditions of Engagement.

The guidelines deal with plant macro-remains, charcoal, waterlogged wood, insects and pollen.

1 Introduction

1.1 Outline

These guidelines are intended to assist Transport Infrastructure Ireland (TII) archaeologists and archaeological consultants working on archaeological testing [Stage (i)], excavation [Stages (ii) and (iii)] and post-excavation [Stage (iv)] phases of archaeological mitigation on national road schemes. The guidelines deal with the stages of retrieval, analysis and reporting of plant macro-remains, charcoal, wood and insects from archaeological deposits, as well as sampling procedures and information retrieval associated with pollen analysis (palynology). Palaeo- environmental services are provided in the context of a managed process within the framework of a standardised contract for the provision of archaeological services procured in accordance with the Department of Finance-approved Standard Conditions of Engagement for Consultancy Services (Archaeological).

The standard archaeological service stages for TII projects are:

Stage (i)	test excavation
Stage (ii)	pre-excavation
Stage (iii)	excavation
Stage (iv)	post-excavation and dissemination

1.2 Why investigate plant macro-remains, charcoal, wood, insects and pollen?

Analysis of palaeo-environmental remains from archaeological excavations can provide a variety of insights into past societies and environments (Murphy and Whitehouse 2007). Cereal grains, nutshells, seeds and fruit-stones represent the most commonly preserved non-wood plant macro-remains. Delicate chaff from arable crops is also frequently recovered. Other plant components can sometimes be preserved, including cereal bran, leaves, bud-scales and thorns. Vegetative tissues (parenchyma) from roots and tubers may also be recovered. Analysis of these plant remains can provide information about diet, agriculture, local environments and a variety of other aspects relating to past societies (McClatchie 2007).

Plant macro-remains such as cereal grains and hazelnut shell are also very useful for radiocarbon dating because short-lived single-entity samples can be dated, and they are not subject to issues like the ‘old-wood effect’ that can affect some samples of wood charcoal, such as oak.

Fig. 1 Investigating landscapes through palaeoenvironmental analyses, Kells, Co. Kilkenny (Studiolab).

Woodland resources, including wood and charcoal, were of enormous importance in the past. Communities during both the prehistoric and historic periods were dependant on woodland resources for everyday living, including construction materials for buildings, manufacture of most implements, firewood and fuel (Kelly 1988; O'Donnell 2007; Stuijts 2007; OCarroll 2011). Woodlands in the surrounding area of an archaeological site would have been exploited and sometimes managed to provide essential raw materials for the community and associated activities. Analysis of wood and charcoal remains can provide functional evidence for various activities at a site, as well as insights into cultural, ecological and economic variables. Certain wood species may have been selected for particular uses, such as structural posts, firewood, pyre fuel and wattle – it is known, for example, that oak was often selected as fuel for prehistoric cremation pyres; oak was also the preferred species for manufacturing charcoal for use in industrial activities such as metalworking (O'Donnell 2007). Analysis of waterlogged wood can be undertaken to investigate dendrochronology (dating of trees through their tree-rings), wood-working techniques and woodland management. Analysis of wooden artefacts can provide insights into wood craftsmanship and cultural selection of wood types, including the use of imported wood.

Fig. 2 Food preparation: experimental processing of cereal grains (Meriel McClatchie)

Insects are the largest group of organisms on the planet and are found everywhere, except in the deep oceans. Typically, the most commonly encountered insect remains in archaeological deposits are beetles, true flies (especially their pupal cases), fleas, lice, ants, bees, true bugs and caddis flies. They feed on a wide range of living, dead and decomposing plant and animal material, including predating on the immature stages of other insects. Insect exoskeletons are made of chitin (similar to cellulose), which readily preserves in waterlogged conditions. Beetles are the most commonly found and studied remains because they are the most heavily sclerotized (i.e. their surface membrane is heavily cross-linked). Many insects have narrow ecological ranges or habitat requirements. This information can be used by the archaeoentomologist to reconstruct past environmental conditions at the local and regional scale. Analysis of insect remains can contribute to an understanding of living conditions within occupation zones, and the use of structures or yards for animal stabling, tanning, wool-processing and butchery activities (Reilly 2011, 2014a). They can also indicate the importation of wood, water, peat, foodstuffs and other materials onto a site (Whitehouse 2007; Reilly 2014a). Certain fly species can help to clarify the length of time bodies were exposed prior to burial (Lynch and Reilly 2012). Insects are also used in wetland contexts to understand local site environment, longevity of site use, and natural and human-forced environmental change (Reilly 2005, 2014b).

While plant macro-remains, waterlogged wood, charcoal and insect remains are usually recovered from bulk soil samples and individual samples taken during an archaeological excavation, pollen remains require a different approach. Pollen grains are tiny (25-120μm) reproductive gamites that can be identified to species, genus or family level, quantified and then graphed, enabling the reconstruction of vegetation types through both space and time. Pollen from on-site or off-site deposits can be analysed to investigate the history of vegetation cover in a localised area or, when extracted from larger lakes and bogs, can provide a more regional and longer-term view of landscape history and change. Targeted pollen sampling can be undertaken on archaeological sites to investigate the former environment in which a particular feature was constructed or utilised, particularly in wetland areas. Recent pollen work at archaeological sites such as burnt mounds and toghers (trackways) has been particularly valuable in demonstrating environmental change and how people used local resources (Overland and O'Connell 2008). It is important to note that multi-proxy investigations – when many strands of evidence are assessed in tandem – can provide a more detailed and multi-dimensional view of landscape change than any single proxy.

1.3 Why take samples?

Archaeological excavation has the potential to generate enormous quantities of material and, as a result, large amounts of data. Prioritisation of certain deposits for analysis should therefore be undertaken, taking into account the research aims of each individual project. This can enable a systematic and focused approach that maximises the potential of data recovered from each site, enables consistent comparison of data within and between sites, and removes irrelevant or redundant variables from consideration. Sampling is the strategy of selecting a smaller section of the population that will accurately represent the patterns of the broader population (e.g. past woodlands and diet; Orton 2000). Sampling (on-site and off-site) should be consistent, well thought-out and undertaken in close consultation with the ***Project Environmental Specialist*** (**PES**). Sampling protocols should be reviewed and assessed throughout the project's duration. When processing of the selected samples has been completed, extraction and identification of the environmental remains can take place. The results can then be integrated with those from other analyses to provide more informed insights into past activities on sites and the landscapes in which they were situated.

Fig. 3 Samples stored in plastic containers (James Eogan, TII)

1.4 Importance of integrating analyses

The combination of diverse datasets and multi-proxy investigations will produce enhanced interpretations when compared with any single approach. Plant macro-remains analyses, for example, should be integrated with those from other environmental remains – such as charcoal, wood, insect remains and pollen – to explore vegetation at a range of spatial and temporal scales. Analyses of vertebrate remains can further assist in interpreting food procurement and farming systems, perhaps demonstrating interdependence between arable agricultural activity and animal husbandry. It is often beneficial to take larger samples, which can then be split into sub-samples to enable a range of analyses on a single deposit.

A range of other scientific analyses can be combined with those carried out on plant macro-remains, charcoal, wood, insects and pollen to provide enhanced interpretations of past activities. Stable-isotope analysis of human and animal bone collagen, particularly using nitrogen isotopes, can provide broad dietary information. Molecular analysis of charred cooking residues and absorbed lipids from vessels can reveal foodstuffs consumed, as can analyses of skeletal indicators relating to diet and health. It is important to ensure that analyses of all environmental remains are fully integrated with other elements of archaeological investigations to achieve scientifically meaningful and cost-effective results.

1.5 Scope of these guidelines

This document provides advice and information on the following typical stages of environmental work during the pre-excavation, excavation and post-excavation phases of a project:

Typical stages in environmental analyses	1) Appoint ***Project Environmental Specialist*** (**PES**) 2) In consultation with excavation team and following a site visit, **PES** devises ***Environmental Remains Strategy*** (**ERS**) – include sampling strategy and sampling locations for bulk samples or pollen core/monolith/spot-samples 3) Establish ***Environmental Register*** (**ER**) to record samples taken 4) Take environmental samples during excavation; Amend **ERS** if appropriate as excavation continues. Includes site visit by **PES** as excavation progresses 5) Process samples; **PES** produces ***Environmental Remains Assessment Report*** (**ERAR**) to provide overview on variety and scale of environmental remains present, as well as highlighting potential material for radiocarbon dating; **PES** updates **ERS** 6) Environmental specialists (archaeobotanist, wood specialist, archaeoentomologist and/or palynologist) analyse samples according to best practice within the specific discipline 7) Environmental specialists produce ***Final Environmental Remains Reports*** (**FERRs**) detailing analyses of plant macro-remains, charcoal, wood, insects and pollen 8) Prepare material for long-term curation 9) **PES** completes **ERS**, noting all analyses undertaken 10) **PES** prepares overview of environmental analyses for publication

Appendix 1 is a flow chart that illustrates the typical process undertaken in response to the standard specification for excavation services procured in accordance with the Standard Conditions of Engagement for Consultancy Services (Archaeological).

The Case studies in Appendix 2 are designed to illustrate the application of these guidelines in practice. Sources of further information are also provided.

1.6 Project commencement

The standard specification for excavation services used on TII-funded projects requires the writing and on-going revision of an ***Environmental Remains Strategy*** (**ERS**) document. This document is effectively a method statement for the environmental archaeology aspects of the project; it should be drawn up by the ***Project Environmental Specialist*** (**PES**). The **ERS** should

- identify the different categories of environmental remains expected to be encountered,
- outline environmental analyses to be completed,
- prescribe the primary and secondary sampling strategies to be adopted by the excavation team(s),
- set out the standards and methods for sample processing, analysis and reporting for each category of environmental remains.

The first phase in this process will be the appointment of a **PES**, which will happen during Stage (ii). The **PES** will provide advice on best practice at each stage of work, thereby ensuring that the sampling strategy and processing of samples are focused on achieving high-quality and meaningful results. Appointment of environmental specialists for analysis of different categories of environmental remains will take place during Stage (iii), although advice from individual specialists may be required during compilation of the **ERS** document at Stage (ii), particularly when dealing with waterlogged wood, insects and pollen. Nearly all excavation projects require analysis of plant macro-remains and charcoal. Where waterlogged deposits are expected, waterlogged wood, insect and pollen specialists are required. In the case of projects where the proposed mitigation involves the investigation of deeply stratified sediments (e.g. peat), and analysis of long-term environmental change and landscape reconstruction, the services of a palynologist (pollen specialist) will be necessary. Depending on the nature of deposits on an individual excavation, several environmental specialists are often required to deal with the variety of remains uncovered. The **PES** can act as an environmental specialist on a project if the **PES** has the relevant qualifications and experience for the particular specialism (see below).

In order to ensure that appropriate advice is provided and best practice is followed, it is important to ensure that the **PES** and each environmental specialist are adequately trained. They should have achieved a qualification in the relevant discipline (minimum level 8 qualification recognised by the Higher Education and Training Awards Council (HETAC) or equivalent qualification) and have post-graduate experience in the analysis of environmental samples. They should also be members of the Association of Environmental Archaeologists

(AEA) or equivalent national body. In addition to this, the **PES** should have at least three years' experience in the analysis of environmental samples, as well as experience in implementing sampling strategies and undertaking sample processing for a variety of environmental remains. For further information on the training and experience requirements for the **PES** and each environmental specialist, see the relevant TII contract for the project (Pt. 1 Suitability Assessment; Pt. 4 Services Requirements).

2 How are plant macro-remains, charcoal, wood, insects and pollen preserved?

2.1 Introduction

In order to decide how and where to sample for specific environmental material, it is important to understand how the remains have become preserved and the type of remains that might be expected on any individual site. Palaeo-environment remains can become incorporated into archaeological deposits through human and animal action, or can be naturally incorporated into both archaeological and naturally-forming deposits, for example through the formation of peat bogs, or silting in lakes and streams. A variety of preservation methods can result in the survival of plant macro-remains, and it should be noted that any individual deposit may contain remains preserved by more than one mechanism. Charcoal is generated from wood coming into contact with fire and becoming charred. By contrast, insects, pollen and waterlogged wood remains are generally only preserved in waterlogged deposits, such as pits, ditches, peat bogs, lakes and urban deposits.

2.2 Charring

On many archaeological sites in Ireland – particularly on well-drained soils – plant macro-remains and wood are preserved only as a result of charring. Charring (also referred to as carbonisation) occurs during a burning event when plant components are incorporated into a fire. When the supply of oxygen in a fire is insufficient for combustion to occur, the plant material is transformed into carbon. Preservation occurs less often when plant material is incorporated into the oxidising conditions of the open flame, where it is more likely to burn away completely. Insects can occasionally be preserved via charring; for example, seed, grain and bean weevils can be found within charred grain or certain wood-boring insects within charred wood.

Fig. 4 Excavation of charred deposits on the floor of a medieval smithy at Ballykeoghan, Co. Kilkenny (James Eogan, TII)

Charred plant macro-remains and charcoal are generally stable, being resistant to chemical and biological breakdown in the ground. Remains can, however, be degraded by mechanical damage, such as post-depositional trampling and careless handling during recovery, as well as by a continuous cycle of wetting and drying and/or freezing and thawing of deposits. The original thatch of medieval and post-medieval structures can also be preserved through smoke-blackening; the tissues are coated in a sterilising layer of soot so that they look as if they have been charred. Fragmentary charred remains can also be present within residues on cooking vessels.

2.3 Waterlogging

Another common method of preservation occurs when plant and animal material is incorporated into deposits under 'anoxic' conditions, whereby air is excluded, and plant/animal tissues do not break down. Anoxic preservation is also commonly referred to as waterlogging and anaerobic preservation. This mechanism can occur in areas with a high water-table (such as occurs at many *fulachtaí fia*), in deposits of a very organic nature (such as ditches, wells and cess pits) and occasionally when deposits are well-sealed, for example by a heavy clay. As well as occurring on archaeological sites, waterlogging is the normal mode of preservation encountered in natural deposits formed in peatlands, rivers, estuaries and lakes. A special kind of waterlogged preservation can also occur in the form of stomach

and other bodily contents within 'bog bodies' preserved in wetland environments. Pollen, insects and waterlogged wood require waterlogged conditions for preservation, while waterlogging is just one of a number of mechanisms by which plant macro-remains can become preserved.

Fig. 5 Excavating a waterlogged trough, Newrath, Co. Kilkenny (James Eogan, TII)

2.4 Mineral replacement

Mineral replacement of plant material and insect remains (often mis-termed mineralisation) typically occurs in cess pits and other deposits where there is a high concentration of calcium salts, principally phosphates, thus rendering the replaced plant tissues and insect exoskeletons resistant to decay. Mineral-replaced material in the form of palaeofaeces (also known as coprolites) can be particularly informative, in that they may supply direct evidence of foodstuffs consumed, as well as preserving pollen grains that reflect the immediate environs of the archaeological site.

2.5 Other less common methods

Desiccation is a mechanism of preservation rarely seen in Irish material, but commonly encountered in arid regions. Desiccation can, however, occur in certain situations in Ireland, for example in well-sealed deposits within upstanding wall structures, including mortar and plaster. Proxy evidence in the form of seed and other plant impressions can also sometimes be observed in ceramic vessels, clay products and metal slag.

3 Sampling

3.1 Choosing a sampling strategy

A sampling strategy should be formulated by the ***Project Environmental Specialist*** (**PES**) at the planning stage of an excavation, i.e. during Stage (ii), when the general extent and variety of archaeological deposits can be ascertained. This will form part of the ***Environmental Remains Strategy*** (**ERS**) document (see Section 1.6). The strategy should be regularly reviewed at fixed points during the excavation to ensure that it is appropriate. It may be amended, for example, if deposits are found to be more truncated than anticipated, or if individual deposits are more numerous or complex than expected.

The **PES** is required to undertake at least two site visits. During Stage (ii), the **PES** will visit the site to inspect each cleaned excavation area. This visit will assist the **PES** in preparing the **ERS** document. During Stage (iii), the **PES** will visit the site as the excavation is progressing to evaluate the sampling strategy with the project team and revise if necessary.

There are many factors to consider when choosing the most appropriate sampling strategy for any archaeological excavation.

- Potential range of environmental remains on-site and off-site – consider evidence from comparable excavations
- Mode of preservation of remains
- Archaeological questions – see Section 3.2
- Can the strategy be integrated with sampling of other environmental remains?
- Spatial scale of site
- Potential effects of post-burial processes and events (taphonomic factors)
- Chronological resolution – is material required for radiocarbon dating?
- Labour availability – e.g. can on-site processing of samples be carried out?
- Transport and storage implications – remember that samples can be bulky if stored unprocessed
- Budgetary constraints

3.2 Typical archaeological questions that may inform a sampling strategy

Recovery, identification and interpretation of plant macro-remains, charcoal, waterlogged wood, insects and pollen can provide useful information on past activities and environments. Typical archaeological questions may include the following:

Fig. 6 Exposure of archaeological deposits during Stage (ii) (James Eogan, TII)

Theme (source of evidence)	**Questions**
Local environment (plant macro-remains, charcoal, wood, insects and pollen)	• Can we detect long-term change in the local environment? • What types of vegetation and trees were growing in the vicinity of the site? • What plant-based resources were available in the area around the site? • Was standing/moving water present in a context? • How did the deposits form, and what can this tell us about interactions between human activity and the local environment?
Functional use and spatial context of archaeological features (plant macro-remains, charcoal, wood and insects)	• Can we determine the function of a site, feature or wooden artefact, e.g. from charcoal types in charcoal-production pits and burial/cremation pits? • Are the environmental remains associated with the primary function of a feature, e.g. building construction, drying kiln or fireplace? • Were certain activities restricted to specific areas of the site? • Can we detect waste-disposal patterns?
Agricultural activity (plant macro-remains and pollen)	• What crops did people grow? • What do the arable weeds tell us about the appearance of fields? • What agricultural practices were carried out (e.g. manuring, ploughing, irrigation)? • Can we detect the accumulation of crop surpluses or intensification in production?
Food preparation and consumption (plant macro-remains)	• What types of foods and drinks were consumed? • Is there any evidence for preparation methods? • Can we distinguish between human and animal foods?
Use of plants and trees for purposes other than foodstuffs (plant macro-remains, charcoal, wood and insects)	• Which plants/trees were used in structures and furnishing materials? • Were plants harvested for use in the manufacture of textiles? • Can we detect the medicinal use of plants or trees? • Is there evidence for woodland management?
Social and cultural issues (plant macro-remains, charcoal, wood, insects and pollen)	• Can we detect social patterning within a site or between sites (e.g. exotic/unusual plants/trees that provide information on status and trade)? • Is there any evidence for 'special' deposits (e.g. around the entrance area of a house)? • Is there evidence for a specific wood selection policy, e.g. for ritual preferences at cremation features?
Chronology (plant macro-remains, charcoal and wood)	• Are the remains of short-lived plants available for radiocarbon dating (such as cereal grains and hazelnut shell) or is there short-lived tree or branch material that will not be subject to the 'old wood' effect? • Is suitable waterlogged wood available for dendrochronological dating?

3.3 Sampling strategies for plant macro-remains, charcoal and insects

The sampling strategy for plant macro-remains, charcoal and insects may comprise one primary method, or the combination of a primary method and secondary methods. Sampling is usually undertaken through the collection of bulk soil samples.

Strategy	Description	Advantages	Disadvantages	Suitability
Blanket	Sampling of every deposit	All preserved remains are likely to be recovered	Rarely practical or advisable. Prioritisation of certain deposits should take place in order to focus on selected material best suited to the aims of the project	**Avoid**
Systematic	Samples are taken according to a clear strategy. Can include a variety of approaches, e.g. sampling of a specified range of deposit types (all pit and ditch fills)	Encourages the archaeologist to consider the types of contexts and remains that may be encountered. Can be adapted as excavation progresses	Requires careful planning. ‘Unusual’ deposits may be missed.	**Can be chosen as a primary method**
Random	Deposits are sampled in a statistically random manner. A random number generator/table can be used to select contexts or areas of a site grid to be sampled	No bias in sampling – carried out in a statistically random manner. Perhaps most useful for large, apparently homogeneous deposits, such as pit/post-hole complexes.	Random sampling must be rigorously followed to be effective. May miss significant deposits such as large concentrations of charred material	**Can be chosen as a primary method**
Judgement	Focuses on deposits that appear to be potentially rich and informative, such as concentrations of charred material or richly organic pit fills	Useful when combined with a primary strategy, e.g. systematic or random	May result in strong bias towards larger, more visible remains (e.g. charcoal, nutshell and cereal grains). Other remains such as cereal chaff and smaller seeds can be under-represented or absent. Also, a ‘charred’ deposit may be rich in wood charcoal, but have few non-wood plant remains present.	**Can be chosen as a secondary method**
Scatter	A number of samples are taken from one deposit. Suitable for larger deposits where environmental remains may not be homogenously distributed, e.g. ditch fills and burnt mounds. Vertical or horizontal ‘column’ samples can be taken.	Can determine if there is spatial patterning of remains within a single large deposit.	Few disadvantages, but should be combined with other strategies	**Can be chosen as a secondary method**
Collection by hand	Picking out visible remains as ‘spot finds’ from a deposit	Provides rapid information on some of the environmental remains present without the need for soil processing, e.g. enables rapid recovery of short-lived remains for radiocarbon dating (such as hazelnut shell)	Rarely appropriate, as it is generally uncontrolled and depends on experience of excavator. Also heavily biased towards larger, more visible remains and is therefore unrepresentative	**Should generally be avoided, except in certain cases (see ‘Advantages’)**

3.4 Sampling strategies for waterlogged wood

Sampling of waterlogged wood should always be undertaken in close consultation with an experienced wood specialist. The nature of the site and feature type will determine what sampling strategy should be followed. Representative sub-sampling of larger pieces of wood can sometimes be undertaken on site, thereby avoiding unnecessary wrapping and transportation of bulky wood samples. It is important to note that waterlogged wood samples must be kept consistently wet and covered after exposure and on-site recording, and also prior to lifting; the precise methods to be followed should be detailed in the **ERS**.

Feature/site type	Strategy
Wooden troughs and associated features (e.g. platform)	Fully sampled because the wood remains are rarely extensive
Larger habitation sites/structures (e.g. togher)	(See Case study 2 in Appendix 2) An entire wooden togher or wattle structure does not usually require 100% sampling. Instead a series of sections at appropriate intervals along the length of the feature should be fully sampled for both wood identifications and woodworking evidence. A similar strategy can be established with the specialist for other large-scale wooden structures.

3.5 Sampling strategies for pollen

In most cases, sampling for pollen analysis is undertaken by the palynologist using specialist equipment. It is therefore essential that the palynologist is engaged at an early stage to determine the best sample locations (on-site or off-site) and types of samples to tackle the relevant research questions. In some cases, pollen data close to the archaeological site may already be available, and this should be used where appropriate (see www.ipol.ie for details of previous pollen studies). Three types of sampling may be appropriate for further pollen work: cores, monoliths and spot samples.

Strategy	Description
Core	A core sample is extracted using specialised coring equipment from locations such as lakes, peat bogs and woodland hollows. The size of the location at which the pollen core is taken will significantly influence the spatial resolution of the pollen data; for example regional data can be derived from large bogs and lakes, while local data (c. 100 m radius) may derive from small woodland hollows. It is usually preferable for the core sampling location to be situated on-site or as close to the archaeological excavation as possible if off-site. Recent research has shown that pollen data and vegetation reconstructions compare more accurately with the archaeological resource when the sampling location is close to the archaeological site (OCarroll 2012). Core samples are useful for multi-proxy studies, including pollen, diatoms, insects, loss-on-ignition and micro-charcoal.

Strategy	Description
Monolith	Monolith samples are normally extracted from on-site natural deposits. A monolith sample is collected from a clean exposed vertical section (e.g. peat face) in a specialised monolith tin. Overlapping monolith samples in individual tins are usually taken.
Spot sample	A spot sample can be taken from archaeological deposits like waterlogged ditches, cess pits, wells or vessels. Spot samples can inform on past diet, plant use and associated vegetation. They are taken in small plastic containers by pressing the container into the sediment.

4 Sample size

4.1 Plant macro-remains, charcoal and insects

Sample volume should be the important determinant when deciding on sample size. Sample weight can more often be affected by stone content, heavy clays and a variety of other factors. Recording of sample volume enables the environmental specialist to determine the quantity of remains per litre of soil, thereby enabling comparison of deposition events between small deposits (such as stake-hole fills) and larger deposits (such as ditch fills). If a deposit is particularly stone-rich, the stones should be removed before processing, making a note of this action in the ***Environmental Register*** (**ER**).

Fig. 7 Taking a soil sample during excavation (James Eogan, TII)

Sample volume will depend on the method of preservation encountered (charred, waterlogged or mineral-replaced). The sample volumes outlined below should be taken from each deposit (after English Heritage 2002; Institute of Archaeologists of Ireland 2007):

Larger sample volumes may be required if multiple categories of environmental remains are to be analysed from a single deposit (e.g. plant macro-remains, charcoal, insect remains and micro-faunal remains). This is because different categories of environmental remains may require different sample processing methods (see Sections 6.1–6.4).

Recommended sample volumes	
Charred and/or mineral-replaced remains	20 litres of sediment
Waterlogged remains	10 litres of sediment
Waterlogged AND charred/mineral-replaced remains in single deposit	10 litres of sediment
Deposit that is too small to achieve the above volumes (e.g. stake-hole or small pit)	All available sediment

Guidelines on recommended sample size for other remains are provided in *Environmental Sampling: Guidelines for Archaeologists* (Institute of Archaeologists of Ireland, 2007).

4.2 Waterlogged wood

The sample size for waterlogged wood will depend upon the reason for sampling. On-site sub-sampling in consultation with the wood specialist may be necessary following completion of a full and complete record of the wood to be sampled. Samples for wood identification need only be 50 mm in length, but must contain the full diameter of the stem so that annual tree-rings can be counted. A similar-sized sample is required for radiocarbon dating purposes. Worked ends can be sub-sampled from the wooden remains following advice from the wood specialist and recording of the remains on a specialised record sheet. Wood pieces that are fully worked along their entire length should be lifted in their entirety for further analysis. In the case of dendrochronological dating of oak, the full circumference/diameter of the timber is required.

4.3 Pollen

In the case of pollen, the sample size will vary, depending on the type of extraction device being used, as well as the nature and depth of sediment under investigation. Some lake cores can be up to 6 m in length, but are typically only 50 mm in diameter. Monolith tins are generally 1–2 m in length; several overlapping monolith samples may be required along the length of a vertical section. In the case of spot samples, pollen analysis can be carried out on very small sediment volumes – in general, only 0.5 litres of sediment is required. If a single sample is being analysed for a variety of proxies (e.g. pollen, insects and diatoms), then a larger sample will be required.

5 Taking and storage of samples

5.1 Overview

A specified archaeologist should be appointed at the excavation site to oversee the sampling programme in accordance with the agreed sampling strategy. This individual should be an archaeologist trained in sampling theory and techniques (the ***Project Environmental***

Specialist can provide training). An ***Environmental Register*** (**ER**) must be compiled for the duration of the project which should include information on the reason for sampling each deposit, in addition to contextual information (see Appendix 2, Case studies).

5.2 Plant macro-remains, charcoal and insects

Bulk samples of soil are taken to enable analysis of plant macro-remains, charcoal and insect remains. In order to avoid contamination, samples should be taken from cleaned surfaces of individual undisturbed contexts, using clean tools. Samples should be stored within clean plastic-lidded buckets or tubs, or strong plastic bags (if bags are used, samples must be double-bagged). It is important to ensure that samples are well labelled (outside and inside the container) and properly sealed, even if being stored for a short period of time. Plasticized labels and permanent markers are essential.

Fig. 8 Recording a soil sample during excavation (John Sunderland, Eachtra Archaeological Projects)

Samples should be kept in a dark, cool environment, away from direct sunlight. This is particularly important in the case of samples from waterlogged deposits, which can deteriorate rapidly if stored in an inappropriate environment. If the material is to be stored for any length of time in an area that is well-lit, it may be advantageous to carefully cover samples, e.g. with black polythene, to exclude light. Long-term storage of waterlogged samples should be avoided where possible. If long-term storage is necessary, advice from an appropriate environmental specialist should be sought to ensure proper sample curation.

Processing of soil samples and completion of the ***Environmental Remains Assessment Report*** (**ERAR**) will be undertaken during Stage (iii); see Section 6.7 for further guidance.

5.3 Waterlogged wood

Waterlogged wood exposed during an excavation should be numbered and recorded on site plans and sections. Where the wood collection is small (e.g. a wooden trough), each wood piece should be recorded on a dedicated timber or worked-wood recording sheet. A sketch and record photograph should also be taken where appropriate. Where there is a large collection of wood (such as a togher or habitation site), it may not be necessary to number and record each wood piece on a plan and wood sheet. Recording methods should be established in consultation with the wood specialist. Once these records are complete, it may then be possible to sub-sample the wood on site, which will avoid costly and time-consuming wrapping, transportation and storage of large waterlogged wood samples. Samples for wood identification and ring-width analysis need only be small (they can be sub-sampled from larger timbers), but should incorporate the whole diameter of the wood piece. Worked ends can also be sub-sampled from larger posts and timbers, and then packed in cling film and/or waterlogged bags and boxes. Wooden artefacts should be treated separately from other samples and should be lifted in their entirety, wrapped and carefully placed in a waterlogged environment.

Oak is the only suitable timber for dendrochronological dating in Ireland. A full section across the circumference of the wood should be removed and then bagged as above; preferably with sapwood intact. A minimum requirement is generally 80 annual tree-rings, with a preferred annual tree-ring count of 100+.

Sample bags should be clearly labelled to note if it is a wood-identification/analysis sample, worked-wood sample or dendrochronology sample. Small to medium-sized samples that have been wrapped and sealed in polythene bags can be stacked in boxes and stored in a cool environment. Larger timbers may require specialised water tanks for storage.

An overview of sampling and recording work undertaken will be included in the ***Environmental Remains Assessment Report*** (**ERAR**). The **ERAR** will be completed during Stage (iii), and it will include information on the variety and scale of waterlogged wood remains excavated.

5.4 Pollen

The palynologist may choose from a variety of tools for pollen sampling, including

- the russian corer (peat bog);

- the piston corer (lake);
- the Wardenaar monolith corer (small hollows in existing woodlands);
- a monolith tin (on-site vertical sections exposed during excavations);
- a clean plastic sample bag (short-term storage of spot samples).

Sampling locations may comprise areas close to the archaeological activity, further away in a nearby lake, bog or marsh site, or where possible within the archaeological site (e.g. waterlogged ditch). An individual sediment sample taken for pollen analysis can also be examined by other specialists, for example to investigate insects, diatoms (unicellular algae to test for water quality, such as salinity), loss-on-ignition (a measure of the organic content in the sediment and possible human disturbance), micro-charcoal (a measure of charcoal content in the sediment and fire in the surrounding area) and testate amoebae (single-celled organisms that can be used as indicators of dry and wet conditions).

Fig. 9 Taking a pollen monolith during excavation (James Eogan, TII)

The sediment is extracted from the core or monolith under the guidance of a palynologist, and is then wrapped in cellophane and aluminium foil in the field and labelled appropriately, noting the bottom and top of each core/monolith section. The location of spot samples from archaeological sites or features should be noted on any relevant site/area/feature plans and sections, and levels should be taken. The location of samples from sediments within or residues adhering to objects should be noted on appropriate illustrations. The samples are then transported to the laboratory and put into cold storage to await analysis.

Radiocarbon dating may be required during Stage (iii) to ensure each pollen core/sample encompasses the relevant period at the associated archaeological site. For example, if a Bronze Age archaeological site is being excavated, then the pollen core/sample should include sediments dating to the Bronze Age. If radiocarbon dating demonstrates that the pollen core/sample does not reflect the period of interest, then further samples may be required whilst the excavation is ongoing.

An overview of pollen sampling and recording work undertaken will be included in the ***Environmental Remains Assessment Report*** (**ERAR**), which is completed during Stage (iii).

6 Processing of samples for plant macro-remains, charcoal and insects

6.1 Overview

To extract the plant macro-remains, charcoal and insects from bulk soil samples, the sample is disaggregated, which enables separation of the relevant material for analysis. The method of extraction will depend on the process by which the environmental remains have been preserved and the type of remains.

The flotation technique is used to process bulk soil samples containing charred and mineral-replaced plant macro-remains, charcoal and insects. These samples can be processed prior to the contents being examined by an environmental specialist, although guidance from the ***Project Environmental Specialist*** (**PES**) is always required.

Bulk soil samples taken for waterlogged plant macro-remains and insect analysis should only be processed by the relevant environmental specialist. Waterlogged deposits – which can be recognised through the occurrence of organic remains, such as leaves, wood and insect sclerites – are processed using the wet-sieving technique or, for insects, the paraffin flotation method.

All processing of samples must take place during Stage (iii), and an overview of results will be included in the ***Environmental Remains Assessment Report*** (**ERAR**).

6.2 Flotation: charred and mineral-replaced remains

Charred and mineral-replaced remains are usually recovered by flotation, which involves the placing of a soil sample into water. When agitated, organic material such as charred and mineral-replaced plant macro-remains, wood and insect remains will be released from the soil matrix and float to the surface, or be suspended in the water, whereas inorganic material will sink to the bottom of the container.

The processing of samples from well-drained deposits that are thought to contain charred and/or mineral-replaced remains can be carried out by the relevant environmental specialist during Stage (iii). Alternatively, the project director may choose to process samples on-site or at a nearby facility during Stage (iii). On-site sample processing must be done in accordance with the 'Environmental Requirements' set out in the Part 4 Services Requirements. Any control measures required under the project's Environmental Operating Plan must be implemented.

On-site flotation is often preferable, though this is dependent on the scale and duration of the project. On-site flotation can be cost-effective, it eliminates the need for storage of bulky samples prior to delivery to the environmental specialist, and it can be helpful in assessing the suitability of a sampling strategy when the excavation is still in progress. The advice of the

PES must be sought prior to commencement of processing to ensure best practice and proper recording procedures.

Requirements for on-site flotation	
Personnel	• Archaeologist(s) trained in sample processing • **PES** to provide training, ongoing advice and quality assurance
Equipment/ Resources	• Processing and recording area • Flotation tank (or buckets and individual sieves if dealing with small number of samples) • Water supply • Adequate drainage • Silt disposal facilities • Mesh/sieves for drying of samples • Drying space – may require external heat source • Recording sheets (e.g. mesh size, volume processed) • Suitable containers (e.g. plastic sample bags) and labelling materials for storage of processed samples

Flotation is usually carried out using a flotation tank, which can be purchased or constructed – the latter option requires detailed consultation with the **PES**, who will be experienced in the requirements of tank construction. Flotation tanks are large containers/barrels that are pumped with a constant flow of water.

In the case of <u>charred remains</u>, a fine mesh (1 mm) is suspended just below the surface of the water, and the soil is placed onto the mesh. As the soil is disaggregated in the flow of water, the organic material floats to the surface and is then caught by a smaller sieve (minimum 0.3 mm or 300µm mesh) at a run-off point. The material that floats and is caught in the run-off sieve is known as the 'flot'. The inorganic material (known as the 'residue' or 'retent') will not float, remaining on the 1 mm mesh. When no more organic material is seen to be floating, this stage of the process is complete. The flot and residue should then be fully dried and bagged, with care being taken to ensure labelling is correct.

Unfortunately the separation of material by this means is not always complete, and inspection of the residue is always recommended in case some plant remains have failed to float – e.g. dense remains, or remains coated with silt or clay. If some charred material has not floated, the residue should be dried and then re-floated. This second phase of flotation should enable all charred material to be properly separated. When dealing with heavy clays that do not disaggregate easily, seek the advice of the **PES**, who may suggest the addition of chemicals to break down the clay and release the organic material.

Fig. 10 On-site flotation of a soil sample (James Eogan, TII)

If mineral-replaced remains are suspected in a sample, the mesh suspended just below the surface of the water should measure a minimum of 0.3 mm, as mineral-replaced remains will not always float.

Simple bucket flotation – which is more suitable when a few small samples of only a few litres are to be processed – involves placing the soil sample into a bucket, which is then filled with water. The sample is gently agitated to release the organic material. The water is then poured into a sieve, with a minimum mesh size of 0.3 mm to catch the flot. This process is repeated several times until no more charred remains are seen to be floating. Inorganic material, as well as some denser organic material, will have collected at the bottom of the container. This 'residue' can be decanted directly into a sieve containing mesh of 1 mm (or 0.3 mm where mineral-replaced remains are thought to be present), and the contents washed in a concentrated flow of water. The flot and residue should then be fully dried and bagged, with care being taken to ensure labelling is correct.

6.3 Wet-sieving: waterlogged plant macro-remains

Plant macro-remains preserved under waterlogged conditions can be extracted using the wet-sieving technique. Wet-sieving is required as waterlogged material will not always separate and float when the flotation technique is applied. Waterlogged remains must be kept wet, or they will shrink and crack when dried. Due to this requirement, wet-sieving should not be carried out on site and is best practised in a laboratory under the direct supervision of the relevant environmental specialist. The sample should be placed onto a sieve with mesh measuring 0.3 mm, or onto a bank of sieves with the smallest mesh measuring 0.3 mm, and the sample washed in a concentrated flow of water, taking care that sieves do not become clogged. When wet-sieving has been completed, waterlogged material must be kept damp in watertight containers.

6.4 Paraffin flotation: waterlogged insect remains

After death, insects disintegrate into the component parts of its exoskeleton i.e. head, pronotum, elytra (wing cases), legs and abdominal sclerites. The first three, particularly the elytra, are robust enough to be preserved and variable enough to permit identification. In general, these fragments are not recognisable to the naked eye and must be extracted from deposits using specialist techniques. Samples for waterlogged insect remains are always processed off-site using the paraffin flotation method in a suitably equipped laboratory that contains a cold and hot water source, and a silt-trap (Coope and Osborne 1968; Kenward 1980; Kenward et al. 1986). The paraffin flotation method concentrates insect remains out of deposits by adhering to the waxy cuticle of the insect exoskeleton, which is then separated

Fig. 11 Laboratory-based paraffin flotation of a soil sample (Eileen Reilly)

from other material using cold water. In general a 0.3 mm sieve is used, with a large mesh sieve (c.1 mm) being occasionally used to separate larger floating organic material. Flots are stored in 70% ethanol, rather than water, to inhibit mould growth.

6.5 Sorting and preparation of processed samples

The residues of flotation samples should be checked for artefacts such as ceramic sherds, lithics and bone, which can be removed by a person trained in identifying such remains (archaeologist or environmental specialist). Such material may also be present in waterlogged samples, and the processed samples from these deposits will therefore need to be checked. The extraction of artefacts should take place before extraction of plant remains/charcoal/etc.

The entire flot and residue should always be sent to the environmental specialist for analysis. The extraction of any plant and insect material by a non-specialist (including large components such as nutshell and charcoal) <u>should never be undertaken</u>, as fractured and poorly preserved material may be missed.

When all archaeological remains have been removed from the residue, permission must be sought from the National Museum of Ireland before the residue can be discarded (see Section 8).

6.6 Other recovery techniques

In the rare circumstances where desiccated remains are suspected, dry-sieving can be carried out without the use of water. Impressions of seeds, leaves, cordage and other organic material on a range of fabrics can be cast using various agents, such as silicone rubber or casting gels used in dentistry. In the case of both desiccated remains and impressions, advice should be sought from the **PES** at an early stage. In the case of impressions on artefacts, advice should be also sought from an experienced conservator and the National Museum of Ireland.

6.7 Reporting

An ***Environmental Remains Assessment Report*** (**ERAR**) is one of the products of the Stage (iii) services to provide an overview of the environmental remains present. The **ERAR** will be completed by the **PES**. This report will indicate the variety of remains recorded (e.g. charcoal, plant macro-remains, insects, etc.) and, through provision of a ranked scale of abundance (rare, common, frequent, etc.), indicate the quantities of remains present. It is important to note that a Stage (iv) ***Final Environmental Remains Report*** **(FERR)**, as detailed below, must <u>always</u> be completed for each type of environmental analysis.

The **ERAR** should also highlight environmental remains that may be suitable for radiocarbon dating, focusing on short-lived single-entity material where possible. Palaeo-environmental samples containing such material can thereby be prioritised for Stage (iv) analysis, enabling their efficient extraction and identification by the specialist prior to submission for radiocarbon dating. In the case of pollen, radiocarbon dating may be required during Stage (iii); see Section 5.4 above.

If any soil sample taken during the excavation is not processed, or if any processed sample is not fully analysed, then clear and detailed reasons for this decision must be provided for each sample in the **ERAR**.

7 Analysis of plant macro-remains, charcoal, wood, insects and pollen

7.1 Plant macro-remains

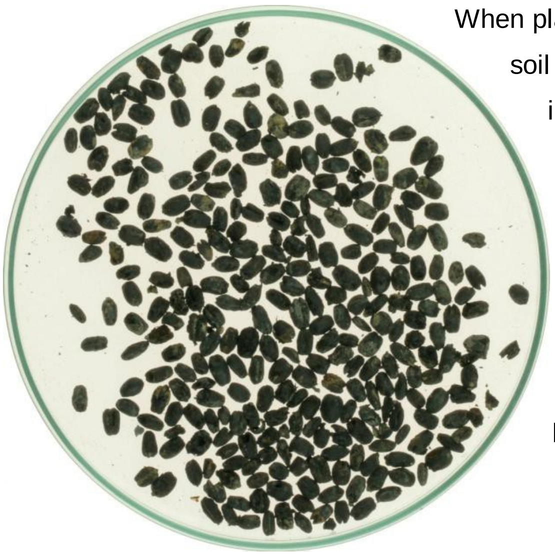

Fig. 12 Charred cereal grains (Rubicon Heritage Services Ltd)

When plant macro-remains have been extracted from the bulk soil samples, identification can take place. Extraction and identification must only be carried out by a trained environmental specialist, who is familiar with the various changes in appearance that the preserved remains may have undergone. The material will often be fragmented, and the analyst must therefore be able to recognise fragments of preserved material and distinguish diagnostic breakage patterns.

In the case of an individual sample containing a very large plant-remains assemblage, sub-sampling may be carried out using, for example, a Riffle box. In this case, it may be decided that only 50% or less of the sample is to be identified, while still ensuring the examination of a representative quantity (van der Veen and Fieller 1982) – at least 300 components should be identified from any individual sub-sample (excluding unidentified seeds, and seeds identified to family level only).

A regional comparative collection of modern specimens (Nesbitt *et al.* 2003) and botanical illustrations (e.g. Anderberg 1994; Cappers *et al.* 2006) are necessary for the identification of preserved material. Access to examples of non-native species that may have been imported – such as exotic fruits – must be available. Identification of most plant macro-remains can be carried out using a stereo light microscope, with magnification ranging from x6 to x40. Some remains may benefit from the application of other microscopy techniques, such as scanning electron microscopy, which provides further depth of field to determine minute anatomical structures.

7.2 Charcoal

Fig. 13 Charcoal remains (Ellen OCarroll)

Decisions are required by the charcoal specialist as to the best method of analysing and sub-sampling the available charcoal remains, because in the majority of cases it is not practical to analyse all samples from a given site and all charcoal fragments from a given sample. The table below is based on recent research by OCarroll (2012), which examined sites from the midlands in Ireland to determine the optimal sample quantities for analysis of charcoal from specific site and feature types (OCarroll 2012; OCarroll and Mitchell 2012).

The process for identifying wood – whether it is charred, dried or waterlogged – involves comparison of the anatomical structure of wood samples microscopically with known comparative material or keys (Schweingruber 1990). A minimum of 30 charcoal fragments, where available, should be identified from each sample. If specific questions in relation to vegetation reconstruction are to be asked of the charcoal resource, more charcoal fragments will require identification (50+).

Charcoal analysis: minimum requirements for sample quantities	
Fulachtaí fia	At least 6 samples from different contexts within a single *fulacht fia*. If a group of *fulachtaí fia* is being excavated at a single location, this sample set may be reduced in consultation with the charcoal specialist
Industrial features (charcoal pits, metalworking features, drying kiln)	At least 6 samples from different contexts
Occupation site	At least 24 samples from various different contexts/features, but note that this number may be increased depending on the complexity of the archaeological features

7.3 Waterlogged wood

Waterlogged wood from archaeological sites can be analysed to determine species and age structure through microscopic identification of wood species and counting of annual tree rings. Wood technology analysis will identify different tool types and wood-working techniques, and may help towards establishing an initial chronological framework for the site, as well as identifying patterns between sites and features (e.g. stone/metal blade types and wood signatures). The samples should be unwrapped, washed and fully cleaned to enable recording and interpretation of tool analysis. Recording of worked ends and toolmarks should follow methods developed in the Somerset levels in Britain (Coles and Orme 1985, 25–50) and the Mountdillon Bogs in Co. Longford (O'Sullivan 1996, 291–357). It is important to note that the samples should remain moist throughout analysis and should not be left to dry out.

7.4 Insects

After insect remains have been separated from palaeo-environmental samples via the paraffin flotation method, sorting and identification can take place. In general, all potentially identifiable insect sclerites (body parts) are extracted from each flot using a stereo light microscope of up to x100 magnification. Identification is carried out by direct comparison of insect sclerites with reference specimens, national or regional museum comparative collections and well-established identification manuals or keys.

Fig. 14 Waterlogged remains of *Rhynolus ater*, a dead-wood feeder associated with oak and pine trees (Eileen Reilly)

Results are generally tabulated into a 'Species list' showing the minimum number of individuals per taxon (species). These lists should also contain known habitat data and any available present-day distribution data for each taxon, ideally in both Ireland and Britain. All subsequent analysis and synthesis of the data is based on this list, so it is vital that the information contained within it is as detailed as possible. Many resources – both published and online – are now available to archaeoentomologists to enhance their analytic work. A basic resource is the BUGS database (www.bugscep.com) and this should be consulted, especially to establish fossil distributions of key species.

There is no agreed 'saturation' point or 'industry standard' assemblage size for insect remains. However, more than 50 individuals per sample are preferable in order to carry out meaningful statistical analysis on the entire assemblage. Analysis of insect assemblages is constantly moving forward as new statistical methods are developed (e.g. Smith 2012). Typical statistics that can be produced from insect assemblages include: *percentage presence of habitat groups* per sample (comprised of ecologically related insects) to show changes in local environmental conditions throughout a site and through time; *species diversity* per sample or per context type e.g. Fisher's alpha (Fisher et al. 1943), particularly useful in identifying 'mixed' deposits or deposits derived from a restricted source; *ordination*, particularly useful for identifying similarities and dissimilarities between insect assemblages across a site and through time for very large groups of samples (e.g. Reilly 2014a). The latter method is also particularly suitable for comparing a number of sites regionally or from the same time period.

7.5 Pollen

The palynologist should make recommendations as to where and how much of each pollen sample should be analysed for vegetation reconstruction. It is critical that dates are obtained at an early stage for the core/monolith/sample. Radiocarbon dates can be obtained from plant macro-remains and peat layers within lake cores and peat cores/monoliths. The palynologist will provide recommendations on which material/sections to date. Advice on suitable sample types and quantities for dating is also available at http://chrono.qub.ac.uk/Resources/Radiocarbon/. Tephra layers (volcanic ash), if present, can also be used in cross-dating a sediment sequence to a particular dated volcanic event. When dates have been established, an age-depth model can then be generated to develop interpolated dates for sections of the core/monolith that have not been dated, thus establishing a chronology for the entire sample. The vertical sampling resolution of the pollen core will determine the temporal resolution of pollen data – the closer together analysed samples are along the length of the core/monolith, the tighter the chronological framework that can be determined. Samples should be taken at 0.04m intervals along a core or monolith, which equates to an approximate time period of 50 years between vegetation reconstructions. Closer sampling intervals can be applied if specific questions are to be addressed which rely on a tighter chronological framework. Spot pollen samples are generally dated through their stratigraphic relationship with the archaeological site or feature.

Samples for pollen analysis are processed in a laboratory using standard techniques (Moore *et al.* 1991). Sediment sub-samples are prepared according to standard procedures of potassium hydroxide digestion, hydrochloric acid treatment, hydrofluoric acid treatment and acetolysis. *Lycopodium* tablets are added to allow the calculation of pollen concentrations (Stockmarr 1971). Samples are then mounted in silicone oil and examined at x400 magnification and under oil immersion at x1000 where necessary. Pollen and spores are identified using various keys and illustrations of Moore *et al.* (1991), the illustrations of Reille (1992) and Beug (2004), and reference material. A minimum of 400 identifiable terrestrial pollen and spores should be counted from each sample, which may rise to 1000 grains depending on the archaeological questions being posed. The resolution and amount of samples requiring identification will depend on dating sequences, particular questions relating to the archaeological resource and period of investigation. The pollen counts are then expressed in a percentage pollen diagram using TILIA 2.0.b.4 (Grimm 1991).

7.6 Reporting

When the environmental remains have been extracted, examined and identified, a Stage (iv) ***Final Environmental Remains Report*** **(FERR)** detailing the results and analysis will be produced by each environmental specialist for each archaeological site. The **FERR** should not be produced until all relevant dating and context information (including radiocarbon dates) is made available to the environmental specialist. It is important that each **FERR** is structured in a clear and understandable manner that will inform the overall archaeological investigation and facilitate production of the relevant Stage (iv) *Final Excavation Report*. In order to achieve this, the environmental specialists must be provided with information on each context examined, as well as overall site and chronological information. Each environmental specialist then has a responsibility to take these datasets into account, and produce **FERR**s that are useful to the excavation director and can easily be integrated into the main Stage (iv) *Final Excavation Report*. On-going communication between the excavation director and each environmental specialist, which may include round-table meetings, is the best means of ensuring the production of good-quality data, appropriate analyses and logical interpretation.

Each Stage (iv) ***Final Environmental Remains Report*** **(FERR)** should include the following:

- Non-technical summary and Statement of significance
- Introduction
- Outline of methods used (sampling, recovery and identification of remains)
- List of remains recorded (by context and species), including exact quantities of each component recovered in table form for plant macro-remains, insect remains, charcoal (count of fragments and aggregate weight) and wood; indicate quantities in chart form in the case of pollen (See Appendix 3 for examples of required formats for species lists)
- Results outlined by phase of activity on the site
- Separate interpretation, taking into account site data provided by excavation director, and also placing remains within intra-site and inter-site context
- Recommendations on potential for long-term curation of remains

8 Temporary and long-term curation of remains

It is important to ensure that any extracted environmental remains are kept in a stable condition during analysis. When analysis has been completed, the plant macro-remains, charcoal and waterlogged wood may be accepted by the National Museum of Ireland (NMI) for long-term curation. The NMI will require each environmental specialist to provide specific recommendations on whether or not the relevant environmental remains from an individual site should be retained for long-term curation. These recommendations can be incorporated into the ***Final Environment Remains Report*** produced by each specialist. The NMI currently makes decisions relating to retention on a case-by-case basis. While charred and mineral-replaced remains may be accepted, waterlogged remains other than wooden artefacts will currently only be accepted in exceptional cases – this is due to this high level of resources required for long-term curation of waterlogged remains. The Archaeological Consultant is encouraged to make contact with the NMI at an early stage should further advice be required.

Recommendations for retention of plant macro-remains and charcoal may include the recovery of unusual or important plant and tree types, and the suitability of material for further scientific analyses. Future investigations may undertake new scientific analyses of excavated material, including further radiocarbon dating. Plant remains – particularly cereal grains, hazelnut shell and fruit stones – are often ideal material for radiocarbon dating and chronological modelling, as they are short-lived single entities (see Ashmore 1999). Another recent development in archaeological science is the exploration of agricultural systems through isotopic analyses of cereal remains. Recommendations against retention of remains may reflect the context from which the material is derived, for example if the material is suspected to be intrusive from modern activity.

In the case where the NMI agrees to accept plant macro-remains and charcoal for long-term curation, the relevant NMI guidelines must be followed when packaging and labelling remains. The budget for each excavation project must take account of the costs associated with preparing material for curation. Preparation of material for curation should be carried out by the relevant environmental specialist. Appropriate containers must be used. Hard-cased labelled vials are suitable in the case of plant macro-remains, which are then placed into plastic bags according to sample/context; the bags can be stored in stackable boxes. Charcoal remains can be stored in small plastic bags within stackable boxes. Material must always be clearly labelled. Charred remains are generally stable and require no further conservation. Waterlogged material must, however, be stabilised. Advice should be sought from the environmental specialist when seeking to stabilise waterlogged remains.

All waterlogged wooden artefacts will generally be acquired by the NMI when conservation has been completed, but confirmation of individual cases should be sought from the NMI. Due to the unstable nature of waterlogged wood and insect remains, their associated storage requirements, as well as the level of ongoing attention these samples require post-storage, the NMI is not currently accepting unworked waterlogged wood or insect remains for long-term storage, except in cases where the assemblage is deemed to be of exceptional interest.

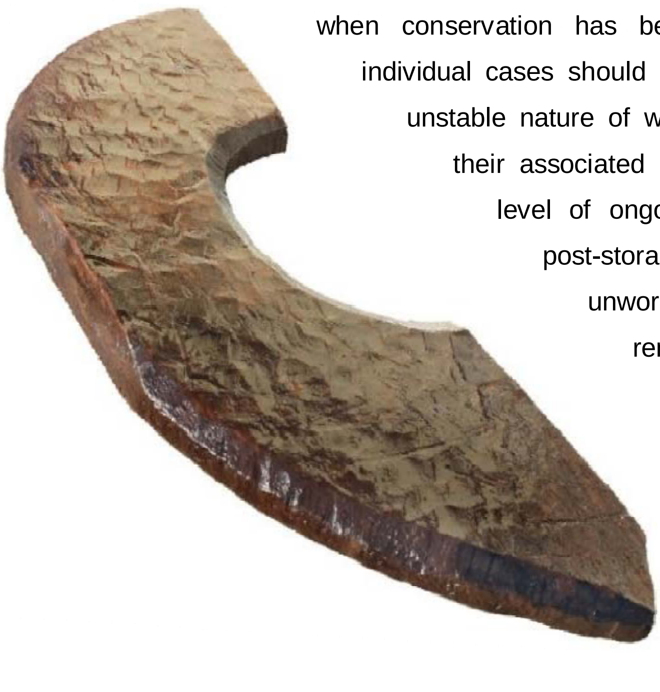

Fig. 15 Conserved wooden block wheel from Edercloon, Co. Longford (John Sunderland, CRDS Ltd)

In the case of pollen samples, the laboratory techniques undertaken in the extraction of pollen and other remains, such as diatoms, destroy the majority of the sediment under investigation. Any sediment that has not been analysed or is surplus to requirements during a particular project can be kept in a cold storage if required for future analyses by the specialist/excavator.

If environmental remains are accepted by the NMI, the ***Project Environmental Specialist*** (**PES**) must submit relevant information to the NMI for the purposes of the NMI database (contact the NMI for further information).

9 Publication

Following completion of the Stage (iv) *Final Excavation Report*, the results from all excavations on each scheme will be synthesised for the production of a single publication. The **PES** will be responsible for integrating and synthesising results from the relevant environmental analyses in accordance with the requirements of the project's publication plan; e.g. the publication plan may require the **PES** to write an overview of results from all environmental analyses on an individual scheme. The budget for each excavation project must take account of the costs associated with preparation of an integrated synthesis by the **PES**.

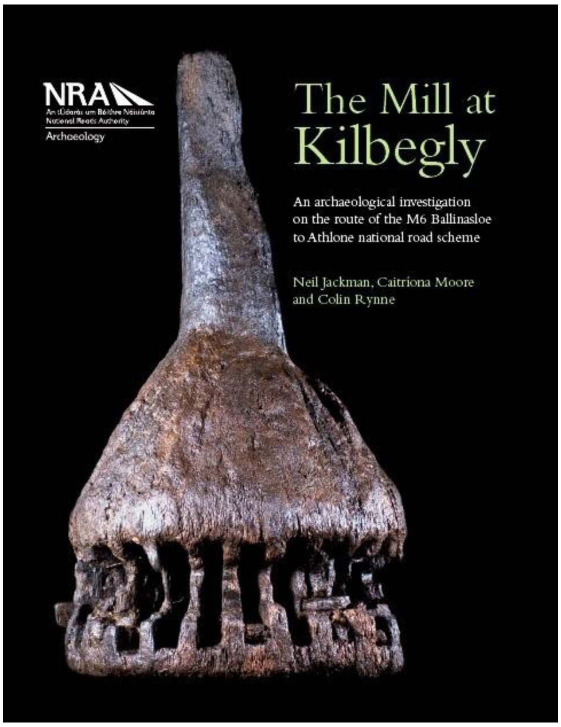

Fig. 16 TII scheme monograph detailing the results of the excavation of an early medieval mill at Kilbegly, Co. Roscommon

In preparing for production of this synthesis, it may be useful to convene a round-table meeting, where results are presented by the excavation director and each specialist. The excavation director should make copies of the entire *Final Excavation Report* available to the specialists in advance of this meeting. This will assist all parties in synthesising their results, and will enable the production of a more integrated and meaningful publication.

10 Further sources of information and references

Advice on all stages of sampling and processing can be sought from the ***Project Environmental Specialist***. The sources and references listed below provide further information for the archaeologist.

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Appendix 1 – Flow chart

St. (ii)	• Appointment of competent, qualified and experienced ***Project Environmental Specialist*** (**PES**) to team • **PES** visits the site to inspect each cleaned Stage (ii) excavation area • **PES** prepares ***Environmental Remains Strategy*** (**ERS**) document in consultation with project team and client
St. (iii)	• **PES** provides any necessary training for project team (taking and processing samples) and establishes ***Environmental Register*** (**ER**) • Sampling strategy is undertaken • **PES** visits each excavation, evaluates sampling strategy with project team and revises if necessary • **PES** inspects/undertakes sample processing or ensures processing is being undertaken by the relevant environmental specialist • **PES** reviews results of excavation and environmental processing • **PES** prepares ***Environmental Remains Assessment Report*** (**ERAR**) for each site excavated • **PES** updates **ERS** and **ER**
St. (iv)	• **PES** oversees specialist analyses • Each specialist produces an individual ***Final Environmental Remains Report*** (**FERR**) for each excavation • **PES** reviews all **FERR**s to ensure that they contain the required information; **PES** collates reports for inclusion in *Final Excavation Report* for each site excavated • **PES** oversees submission of environmental remains to National Museum of Ireland (if accepted by NMI) • **PES** prepares environmental remains summary for publication • **PES** updates and closes out ***Environmental Remains Strategy*** (**ERS**)

Appendix 2 – Case studies

In order to demonstrate how the guidelines can be applied, two case studies are presented below, focusing on the sampling and analysis of remains from a ditched enclosure and a waterlogged settlement site.

A.2.1 Case study 1: Ditched enclosure

The site being excavated is a ditched enclosure, identified during Stage (ii) of investigations. The ditch is substantial, measuring over 2 m in width. The enclosure contains two circular house structures and other nearby features, such as hearths and pits. Further features may be revealed as the excavation takes place.

A.2.1.1 Research questions

Research questions appropriate for this site could be:

- Is there any evidence for plant foods that people were consuming and/or food preparation activities?
- Can we identify wood-selection policies in relation to firewood and structural use?
- Are the environmental remains associated with the primary function of a feature, e.g. building construction, drying kiln or fireplace?
- Can we determine differential use of space within the enclosure and ditch, including areas for waste disposal?
- Is there evidence for 'founder' organic deposits placed in the foundations of a structure?
- If occupation of the site is relatively long-term, can we determine changes in plant use and selection of trees types over time?
- Is there material in the ditch that could provide information on the local environment?
- Do we need material for radiocarbon dating?

A.2.1.2 Suggested sampling strategy

It is important to assess results from other comparable sites when deciding how to structure any individual sampling strategy. The ***Project Environmental Specialist*** (**PES**) can provide advice on the quantity and range of material to be expected.

Most of the sediments at this site appear to be well-drained, and it is therefore expected that most environmental remains will have been preserved through charring. Evidence from other comparable sites does, however, suggest that there may be some waterlogging at the base of the ditch.

Fig. 17 Sampling ditch fills at Baysrath, Co. Kilkenny (Bernice Kelly, TII)

Ditches are excellent receptacles for waste and often contain evidence for plant, animal and wood resources available to the site's inhabitants. Furthermore, ditches can contain evidence for deposition events over decades, thereby providing an overview of long-term activity at the site, as reflected by changes over time in the plant macro-remains, charcoal and insect assemblages. If the basal deposits of a ditch are waterlogged, local vegetation and insect communities may be represented in deposits, giving insights into the background environment. Charring is often biased in favour of plants that are more likely to come into contact with fire, such as cereals dried before storage and wood selected for fuel, whereas waterlogging is not as discriminatory. If waterlogged deposits are found at the base of the ditch, they may also be suitable for pollen analysis and for the recovery of spot samples pertaining to the environment at the early phases of construction and occupation of the site.

House structures may contain domestic debris within floor deposits and structural features, including foodstuffs. Charcoal associated with the house structures may reveal the types of wood that were selected for constructional use. Plant-macro remains from internal and external pits and hearths may reveal associations with food processing and/or waste deposition. The identification of charcoal from pits may help to determine functional use, such as charcoal-production pits, or contribute to an understanding of processes such as cremation. Analysis of charcoal from hearths may also highlight firewood selection strategies.

This type of site has, therefore, high potential for yielding significant charcoal, plant macro-remains and insect assemblages (the latter from the ditch fills), which will provide insights into past activity and environment at this location. The primary sampling strategy could be 'systematic', whereby there is a focus on structural features, with a lesser number of samples taken from external and internal features. Starting with the ditch, 'column' sampling may provide evidence for changing activities at the site over time, whereby a bulk sample is taken from each deposit in a vertical column. The basal deposit may contain evidence for the local environment when the ditch was constructed, the remains of plants, trees and insects having become incorporated into the basal deposit during initial silting of the ditch. Deposits towards the middle of the ditch may contain evidence for different episodes of activity, or indeed some may be archaeologically sterile, suggesting inactivity. Upper deposits may then contain evidence for the final phases of activity at the site before it went out of use. Within the enclosure, it may be advantageous to focus on structural features from the houses, which can include material deposited during their construction as well as household debris, such as floor sweepings, that became incorporated into deposits. The taking of a smaller number of samples from internal and external features, such as pits and hearths, can also provide information on differential use of space within the enclosure and houses.

The systematic strategy could also be accompanied by scatter sampling of particularly large deposits in the ditch, which may detect different activities in an apparently single homogenous deposit. Judgement sampling may also be required to establish a robust chronology for the site. In this case, certain deposits should be sampled to provide material for radiocarbon dating – note that a relatively large number of samples may be required to ensure that single-entity samples derived from short-lived species are available for radiocarbon dating.

	Environmental remains		**Sampling strategy**		
	Charred	Waterlogged	Systematic	Scatter	Judgement
Ditch (upper fills)	x	..	x	x	..
Ditch (lower fills)	x	x	x	x	..
House structures	x	..	x	..	..
Pits	x	..	..	..	x
Hearths	x	..	..	..	x

Table: Overview of preservation potential at this site and proposed sampling strategy

In terms of volume, 20 litres should be taken from deposits where charred material is expected. If deposits are too small to allow this level of sampling, the entire deposit should be sampled. In the case of any waterlogged ditch deposits, 10 litres will be sufficient.

In terms of the number of samples to be taken, this will depend on the volume and extent of available deposits at each individual site. In the case of charcoal, previous research by OCarroll (2010; 2012), based upon archaeological sites in the Irish midlands, indicates that a minimum of 24 charcoal samples are required for a representative species count at this type of site. If an archaeological site contains a number of individual features that are likely to yield significant plant macro-remains and charcoal assemblages (e.g. drying kilns and metalworking activity), a greater number of charcoal samples will be required. It is important to discuss and amend sampling strategies with the **PES** as the excavation progresses.

The sampling strategy outlined above is based upon expected deposits, as identified during Stage (ii) of investigations. Changes to the sampling strategy may be required as the excavation continues, perhaps due to the discovery of new and unexpected deposits. It may be found that two supposed hearths discovered during Stage (ii) are in fact complex drying kilns. Such features are likely to contain evidence for food-production, structural wood and firewood strategies at this site, and should therefore be subject to detailed sampling, taking separate samples from the various constituents of each kiln, such as the fire-setting, the bowl area, the flue, evidence for collapsed roofing, etc. Modification of the sampling strategy may also be required if deposits are truncated or have been subject to modern disturbance, e.g. through animal burrowing. In these cases, fewer samples may be required than set out in the sampling strategy. It is therefore necessary to regularly review the sampling strategy in close consultation with the **PES** as the excavation progresses.

A.2.1.3 Stages of work and required personnel/resources

The stages of work detailed below are based on the premise that sampling for plant macro-remains, charcoal and insects is being undertaken at this site. If waterlogged deposits within the ditch (and/or other 'cut' features) are also to be sampled for pollen analysis, a palynologist should be engaged at an early stage to provide advice and carry out sampling.

Key: A = Excavation director; B = On-site Sampling Manager (See Section 5.1); C = Archaeologist(s) with specific training to carry out this task, e.g. sieving of soil samples (See Section 6.1); D = ***Project Environmental Specialist*** (**PES**); E = Individual environmental specialists

Stage of work	Stage	Personnel required	Resources required	Document output
Choose sampling strategy	Pre-excavation: Stage (ii)	A D	Overview of extent/range of archaeological features expected Knowledge of results from comparable sites Site visit by **PES** Detailed communication between **PES** and excavation team The **ERS** document is prepared by the **PES**	***Environmental Remains Strategy***
Apply sampling strategy	During excavation: Stage (iii)	A B D	Suitable sample containers (tubs/bags) Labelling materials Storage facilities Ongoing review by **PES** to ensure strategy is appropriate (including site visit)	***Environmental Register*** (catalogue of samples taken) Revised ***Environmental Remains Strategy*** (if amended)
Process soil samples **Extract artefacts from processed samples**	During excavation: Stage (iii)	A C D E (in the case of waterlogged samples)	**Charred/mineral-replaced remains**: Advice from **PES** Processing area Recording sheets Flotation device Access to water, drainage, silt disposal Drying area – may need external heat source Mesh for drying samples Containers and labels for processed samples **Waterlogged remains**: Processed off-site by the individual environmental specialists In all cases, the **ERAR** is prepared by the **PES**	Updated ***Environmental Register*** (include catalogue of flots, residues and extracted artefacts) ***Environmental Remains Assessment Report*** (variety and scale of remains; highlight potential material for radiocarbon dating)
Extract and identify plant macro-remains, charcoal and insects from processed samples	Post-excavation: Stage (iv)	E	Carried out by individual environmental specialists	
Report on results of plant macro-remains, charcoal and insect analyses	Post-excavation: Stage (iv)	A D E	Detailed communication between environmental specialists, **PES** and excavation team, which may include round-table meeting Each **FERR** completed by individual specialist	***Final Environmental Remains Reports***
Prepare material for long-term curation	Post-excavation: Stage (iv)	E	Carried out by relevant environmental specialists	
Integrate plant macro-remains, charcoal and insect results into text of main excavation	Post-excavation: Stage (iv)	A D	Detailed communication between **PES** and excavation team	*Final Excavation report* Close out ***Environmental***

Stage of work	Stage	Personnel required	Resources required	Document output
report				***Remains Strategy***
Prepare publication	Post-excavation: Stage (iv)	A D E	Detailed communication between **PES**, individual specialists and excavation team, which may include round-table meeting **PES** prepares synthesis of environmental analyses for publication	Synthesis publication

A.2.2 Charcoal sampling strategies for specific dryland site / feature types

A.2.2.1 Industrial: metal-working kilns, drying kilns and charcoal-production kilns / pits

Industrial features such as metal-working kilns, drying kilns and charcoal pits provide evidence for the exploitation of wood as an energy source. In some cases, large charcoal brushwood fragments are preserved in charcoal pits, which can be analysed to determine the exact nature of the woodland associated with the charcoal pits and any woodland management practices. According to OCarroll’s study of archaeological sites from the Irish midlands (2012), at least six samples from different contexts should be taken from these types of features (see Section 7.2).

Fig. 18 Medieval keyhole-shaped cereal drying kiln, Ballykeoghan, Co. Kilkenny (James Eogan, TII)

A.2.2.2 Fulachtaí fia

Charcoal analysed from *fulachtaí fia* sites can be very useful in reconstructing local vegetation (O'Donnell 2011). *Fulachtaí fia* or burnt mound sites often contain large quantities of charcoal, representing events over a period of time, rather than a single episode or constructional event. It is believed that the wood used at *fulachtaí fia* was collected from trees located in close vicinity to the site, rather than selected from further away; *fulachtaí fia* are therefore presumed to be valid indicators of natural vegetation associated with a particular time period and location (OCarroll 2012). The main use phase of *fulachtaí fia* spans nearly three millennia (3000–500 BC) making these sites particularly useful for determining long-term environmental change.

The burnt mound material should be bulk sampled across the deposit using the scatter sample strategy (see Section 3.3). This can help determine spatial patterning within the burnt mound material and will better incorporate all taxa used for firewood at the site. Samples should also be taken from different deposits throughout the trough to determine if different woodland types were being exploited over time. Recent research using techniques such as saturation curves to determine the optimal number of samples required to identify the range of taxa at an individual site has shown that at least six samples are required for optimal species determinations in relation to charcoal analysis at *fulachtaí fia* (OCarroll 2012; OCaroll and Mitchell 2012; see Section 7.2).

A.2.2.3 Funerary sites: cremations

In the case of cremation burials, the entire deposit should be sampled and sieved (in consultation with an osteoarchaeologist). Nearby non-funerary contexts should also be sampled for comparative purposes. Cremation pits are one of the most common features associated with Bronze Age funerary rites in Ireland. The charcoal associated with the cremated human remains can be viewed as symbolising a connection and association with their surrounding landscapes and woodlands. In most cases, oak and/or Maloideae-type are the only charcoal taxa identified from these cremation pits, which indicates a selection policy relating to specific wood types. Oak is one of our few native taxa that can reach temperatures of between 650° and 850°, which is the temperature required to efficiently cremate human bone (O'Donnell 2007).

Fig. 19 Sampling of the charcoal-rich secondary fill of an Iron Age penannular ring-ditch at Coolnaveagh, Co. Wexford (Bernice Kelly, TII)

A.2.3 Case study 2: Waterlogged settlement site

The site being excavated is located within a waterlogged environment and was identified during Stage (ii) of investigations. The site lies at the edge of a peat bog and is preserved through the anaerobic preservation qualities of the peat. The site comprises the remains of a wooden roundhouse, toghers, hearths and associated pits and other deposits. Further features may be revealed as the excavation takes place.

Fig. 20 Waterlogged remains of a Bronze Age house, Clonfinlough, Co. Offaly (Conor McDermott, Irish Archaeological Wetland Unit)

A.2.3.1 Research questions

Research questions appropriate for this site could be as follows:

- Can we establish what activities were taking place at this location?
- Can we identify wood-selection policies in relation to structural use and firewood?
- Can we determine differential use of space in the occupation area, including waste disposal areas?
- What can we learn about the wider landscape, and can sampling of deposits reveal local as well as site-specific environmental information?
- Is there any evidence for plant foods that people were consuming and/or food preparation activities?
- Is there any evidence for construction materials?
- If occupation of the site is relatively long-term, can we determine changes in plant use and selection of wood types over time?
- Is there any evidence for woodland management?
- Is there any evidence for trade through the identification of non-native wood and insect species?
- Do we need material for radiocarbon dating or dendrochronological dating?

A.2.3.2 Suggested sampling strategy: charcoal, plant macro-remains and insects Results from other comparable sites should be assessed when deciding how to structure the sampling strategy for this site. The nature of deposits and sediments at this site are waterlogged – expected environmental remains will therefore have been preserved through waterlogging as well as charring.

Testing work during Stage (ii) established that waterlogged wood should be expected from the house structure, palisade and associated toghers. Occupational features and deposits, such as hearths, floor deposits and pits, and deposits of human and animal faeces are also likely to contain charred and waterlogged plant-macro remains, charcoal and insect remains. It is important to note that the presence of waterlogged plant remains means that bulk soil samples should not be processed by flotation, but rather by wet-sieving, and paraffin flotation in the case of insects.

The sampling strategy for retrieval of plant macro-remains, insects and charcoal is similar to Case study 1, whereby a systematic or random sampling strategy could be implemented. Charcoal analysis can help in determining wood selection for structural features and firewood, as well as temporal landscape reconstruction if the settlement site spans many different periods of use. Sampling of plant macro-remains is likely to provide insights into plants that would have been growing locally, as well as plants that were cultivated and gathered as foodstuffs. Insect analysis is likely to provide insights into local ground conditions underfoot, differential use of space within the occupation zone and identification of waste disposal areas. Samples should be taken from both occupation layers (where present) and cut features (including pits, foundation trenches, post-holes, stake-holes and hearths). In the case of large deposits (e.g. large pits), a number of samples should be taken from a single deposit to determine if spatial patterning is occurring within the deposit.

In terms of volume, 10 litres is usually sufficient for deposits that are waterlogged. Larger samples should, however, be taken where any individual deposit will be examined by a number of specialists, e.g. for analysis of plant remains, charcoal and insects.

A.2.3.3 Suggested sampling strategy: waterlogged wood

A separate sampling strategy is required for the waterlogged wood components of the site. This sampling strategy should be established during Stage (ii) in consultation with a waterlogged wood specialist and the National Museum of Ireland. A minimum of 33% of all wood remains exposed should be sampled.

On-site recording and sampling can be undertaken where large quantities of wood are being excavated, as is expected at this site. A wood specialist is required on site for a large majority of the excavation to oversee the recording and sub-sampling of wooden remains. The advantage of this approach is that a large portion of the sampling and recording can be completed during excavation, thereby reducing the amount and size of samples to be analysed in post-excavation Stage (iv). If a wood specialist is not present at the site during portions of the excavation, then all wood should be lifted in its entirety for further analysis.

Fig. 21 Waterlogged wood being recorded prior to sampling, Newrath, Co. Kilkenny (James Eogan, TII)

The location of wood samples taken from features such as posts, houses, wattle walls, toghers and wooden floor surfaces should be recorded onto any plans or section drawings. The location of bulk wood samples should also be recorded on plans and sections. Wattle structures may need to be drawn at a larger scale than other site/feature plans. In the case of worked wood, a worked-wood recording sheet, including a record of the full dimensions of the wood piece, should be completed on-site to obtain as much information as possible whilst in the field. Samples should then be lifted and bagged in a watertight sample bag or wrapped in cling film. Larger samples may require immersion in water-tight containers and may then be covered with black plastic. Sample bags should be clearly labelled to denote the sample type, such as wood identification sample, worked wood sample or dendrochronology sample.

The sampling and recording of timbers on-site is time consuming, and a designated team should be responsible for this work to ensure the integrity of the archaeological record. A processing area should be created close to the site, at which samples can be processed for recording, e.g. completion of timber and woodworking sheets, and sub-sampling.

The site outlined above can be divided up into separate components and sampled accordingly, as described below. Roundwood is defined as a timber in the round and measuring over 60 mm in diameter. Brushwood measures less than 60 mm in diameter.

Wooden palisade and wooden posts associated with house/hut structures: Each individual post should be sampled for both wood identification and wood-working analysis. The posts may be sub-sampled on-site to avoid large and bulky sample quantities (e.g. a small transect of the post for wood identification and the worked end for tool analysis).

Hurdle/wattle structures: Wood recording sheets specifically designed for recording the weave of wattle should be used. It is important to locate individual rods and sails. All sails should be sampled for wood identification and woodworking evidence. The rods should be bulk sampled every 2–3 m so as not to duplicate wood remains.

Plank toghers, wooden door sills and any other large timber structural features; all elements (split timbers, uprights, miscellaneous pieces) should be sampled for wood identification and wood-working technologies.

Roundwood/brushwood toghers: a full transect across the width of the structure is recommended every 1 m. This is dependent on the orientation of the elements – e.g. in the case of toghers containing predominantly longitudinal elements, the spacing of samples should be adjusted in accordance with the length of the pieces.

Roundwood/brushwood platforms or wooden floors: a transect across the full width of the floor should be sampled to avoid duplication of wood samples.

Wooden artefacts: find location should be recorded and the artefact lifted in its entirety for further identification, analysis and conservation.

Fossilized trees: a tree recording sheet should be used to gain as much information as possible, and the material should be sampled for wood identification.

A.2.3.4 Stages of work and required personnel/resources

Key: A= Excavation director; B = On-site sampling Manager (See Section 5); C = Archaeologist(s) with specific training to carry out this task, e.g. basic wood recording; D = ***Project Environmental Specialist*** (**PES**); E = Individual environmental specialists

Stage of work	Stage	Personnel required	Resources required	Document output
Choose sampling strategy	Pre-excavation: Stage (ii)	A D E	Overview of extent/range of archaeological features expected Knowledge of results from comparable sites Detailed communication between **PES**, excavation team and environmental specialists Site visit by **PES** The **ERS** document is prepared by the **PES**	***Environmental Remains Strategy***

Stage of work	Stage	Personnel required	Resources required	Document output
Apply sampling strategy	During excavation: Stage (iii)	A B D E	Suitable sample containers (tubs/bags) Labelling materials Storage facilities Ongoing review by **PES** and environmental specialists to ensure sampling strategy is appropriate (including site visit by **PES**)	***Environmental Register*** (catalogue of samples taken) Revised ***Environmental Remains Strategy*** (if amended)
Process wood samples	During excavation: Stage (iii)	A C D E	Processing area Wood recording sheets Suitable sample containers (boxes/bags) Labelling materials Storage facilities Samples should be packed, labelled and boxed in consultation with the wood specialist	Updated ***Environmental Register*** (include wood recording sheets)
Process soil samples **Extract artefacts from processed soil samples**	During excavation: Stage (iii)	D E	Waterlogged and charred remains are likely to be present in the soil samples. Processing should therefore be carried out in the laboratory by the relevant environmental specialist (archaeobotanist/ archaeoentomologist). In all cases, the **ERAR** is prepared by the **PES**	Updated ***Environmental Register*** (include catalogue of flots, residues and extracted artefacts) ***Environmental Remains Assessment Report*** (variety and scale of remains; highlight potential material for radiocarbon and dendrochronological dating)
Extract and identify plant macro-remains, charcoal, wood and insects from processed soil samples **Analyse wood samples**	Post-excavation: Stage (iv)	E	Carried out by individual environmental specialists	
Reports on results of plant macro-remains, insect, charcoal and wood analysis	Post-excavation: Stage (iv)	A D E	Detailed communication between environmental specialists, **PES** and excavation team, which may include round-table meeting Each report completed by individual specialist	***Final Environmental Remains Reports***
Prepare material for long-term curation	Post-excavation: Stage (iv)	E	Carried out by relevant environmental specialists, and where necessary, conservation specialists	
Integrate plant macro-remains, charcoal, wood and insects results into text of main excavation report	Post-excavation: Stage (iv)	A D	Detailed communication between **PES** and excavation team	*Final Excavation report* Close out ***Environmental Remains***

Stage of work	Stage	Personnel required	Resources required	Document output
				Strategy
Prepare publication	Post-excavation: Stage (iv)	A D E	Detailed communication between **PES**, environmental specialists and excavation team, which may include round-table meeting **PES** prepares synthesis of environmental analyses for publication	Synthesis publication

A.2.3.5 Suggested sampling strategy: pollen

Existing palaeo-environmental information relating to this location may already have been produced, and this should be investigated and used as appropriate (www.ipol.ie). Samples for pollen analysis should only be taken in consultation with the palynologist. Coring and monolith pollen sampling is generally carried out by the palynologist with specialist equipment. Spot samples may be taken by the sampling manager in consultation with the palynologist.

The pollen sampling strategy should be decided upon during Stage (ii). A multi-proxy approach is widely accepted as the most appropriate method of understanding the archaeology of wetlands. The principal techniques that can be applied include pollen, testate amoebae, plant macro-remains, insect, wood and charcoal analyses from cores and bulk samples. A single core or monolith sample can be used for a range of proxies or techniques. Pollen analysis can address specific landscape and archaeological questions relating to the period when the site was in use, as well establishing the environment that existed prior to the site being constructed and following abandonment of the site.

Samples for local environmental reconstruction can be taken at the edge of the settlement site in undisturbed peat sediment. The samples are taken using a series of monoliths tins or a russian corer, depending on the depth of peat or sediment that is to be sampled. Regional environmental reconstruction can be inferred from a long peat core close to the excavation site or a lake core taken some distance from the site with a piston corer.

Monolith tins should be placed into the peat section straight (vertically) and then knocked in with a mallet. Where multiple tins are placed in the section, they need to overlap by about 5 cm to record the full sequence of the peat section. The top and bottom of each monolith should be tied into Ordnance Datum (OD), and the location should be recorded on section drawings. To remove the tin from the section, either lever the tin out with a spade from the back, or cut around the tin using a spatula or trowel. Wrap the tin in cling film, and clearly label the top and bottom of the tin, making sure to also label the sample with the name of the site, monolith number and depth (cm) from where the tin was placed in the section.

After the sediment is extracted from the peat or soil using a core (Russian or piston), it is then transferred onto plastic guttering of appropriate length, wrapped in cling film, and the site name, core number, top and bottom of each core, and depth clearly labelled. All coring locations should be recorded on site plans, as well as noting the level from the surface where the core was taken. If a core or monolith is taken from an off-site location, its position should be tied in to the National Grid. All core samples must be put into cold storage to preserve the sediments for analysis.

During analysis, the core/monolith is recorded in detail and the sediment is described. The core/monolith is then sampled into individual blocks, and macro remains from within the sediment are dated to determine which sections of the core/monolith should be the focus of analysis. This work is usually carried out at post-excavation Stage (iv). It may, however, be prudent to carry out initial dating of the core or monolith during excavation Stage (iii) to ensure that the pollen samples are associated with the period of archaeological activity under investigation.

Spot samples for pollen analysis can be taken from peat layers below, above and within the archaeological wooden remains. Each sample should be placed into a plastic bag and labelled appropriately. Spot samples can provide insights into local environmental conditions at the site immediately before it was constructed, during its use phase and after the site was abandoned. The spot samples should be large enough to be used for a variety of different proxies (e.g. pollen, insect remains, plant remains, etc.).

Appendix 3 – Required format for species lists and pollen diagram

Plant macro-remains

Botanical name	**Common name**			
Corylus avellana L. (shell fragment)	Hazelnut	...	7	...
Ranunculus acris L. (achene)	Meadow buttercup	...	1	...
Urtica dioica L. (achene)	Common nettle	...	2	...
Chenopodium album L. (utricle)	Fat-hen	13	7	...
Persicaria maculosa Gray (achene)	Redshank	2	...	1
Raphanus raphanistrum ssp. *raphanistrum* (pod fragment)	Wild radish	...	...	12
Vicia spp. (seed)	Vetches	1	...	...
Linum usitatissimum L. (seed)	Flax	...	...	6
Carex spp. (achene)	Sedges	...	...	3
Avena spp. (grain)	Oat	5	...	13
Avena sativa L. (floret base)	Cultivated oat	...	...	2
Hordeum vulgare var. *nudum* (grain)	Naked barley	15	...	...
Hordeum vulgare L., hulled (grain)	Hulled barley	235	34	...
Secale cereale L. (grain)	Rye	1	...	...
Triticum cf. *aestivum* L. (grain)	cf. Bread wheat	...	...	3
Triticum spp. (grain)	Wheat	17	...	...
Triticum spp. (glume base)	Wheat	4	...	...
Cerealia (grain)	Indeterminate cereal	2	2	...
Cerealia (grain fragment)	Indeterminate cereal	31	45	...
Cerealia (lemma fragment)	Indeterminate cereal	1	...	2

1. Format: The table must be structured to clearly show the plant remains recorded per sample.

2. Order: List the plant macro-remains following the order and nomenclature of a well-known flora, such as *New flora of the British Isles* or *Flora Europaea*.

3. Plant names: Include botanical (usually Latin) and common (English) names, including the authority (e.g. “L.”). Also include the plant part recorded.

4. Quantities: Include exact quantity for each species per sample in table form as above.

5. Volume of sediment processed (See Section 4.1 for further information): Include volume (litres) for each sample. Also include total number of components per sample, in addition to total number per litre of sediment processed.

Charcoal

Site number/ name	Context number	Sample number	Flot weight (grams)	Context description	Wood identifications	No. of fragments	Charcoal weight (grams)	Size of fragments (mm)	No. of growth rings	Growth ring curvature	Comments
E465	98	19	475.9	Primary fill of pit C119	*Alnus glutinosa* (alder)	36	4.7	5–25	3–9 rings	weak	Iron stained
					Fraxinus excelsior (ash)	2	0.1	5–9	3–4 rings	weak	
					Corylus avellana (hazel)	10	1.8	3–10	3–6 rings	weak	
					Prunus spinosa (blackthorn)	5	0.3	4–8	3 rings	strong	Suitable for dating
					Prunus avium/padus (cherry)	8	0.6	5–7	3–4 rings	weak	
					Maloideae (apple/pear/hawthorn/mountain ash)	20	1.5	4–10	2–4 rings	moderate	
					Quercus sp. (oak)	3		2–6	3–10 rings	weak	
					Ulmus sp. (elm)	6	0.2	4–8	3–5 rings	weak	
					Salix sp. (willow)	6	0.3	5–10	3–6 rings	weak	
					Ilex aquifolium (holly)	1	0.5	5 –7	3–4 rings	strong	
					Prunus sp. (blackthorn/cherry)	1	0.05	4–10	3–6 rings	weak	
					Betula sp. (birch)	2	0.01	2–6	3 rings	weak	
					Viburnum opulus (dog rose)	3	0.6	4–8	3–4 rings	weak	
					Taxus bacatta (yew)	5	1.0	5–10	2–4 rings	strong	
					Ulex sp. (furze)	2	0.05	5–9	3–4 rings	strong	
					Frangula alnus (alder buckthorn)	13	1.8	3–10	3–6 rings	weak	
					Euonymous europaeus (spindle)	5	0.5	4–8	3 rings	weak	Ring width 1–2mm
					Hedera helix (Ivy)	3	0.6	5–7	3–4 rings	weak	
					Cornus sanguinea (dogwood)	3	0.1	4–10	2–4 rings	weak	

1. Taxonomy: All taxon names should be presented by their botanical name (usually Latin; genus/species italicized; family name not italicized) and by their common name (English) in brackets after the botanical name. Anatomical characteristics of charcoal fragments do not always allow for identification to species level. Several species cannot be separated anatomically and are instead classified as groups of species, genera, sub-families and families. Examples in this table include *Quercus*, *Ulmus*, *Salix*, *Ulex*, *Prunus* and *Betula* genera (identified to indeterminate species level or “sp.”) and Maloideae (identified to family level).

2. Quantities: Include exact quantity (weight and number of fragments) for each taxon per sample in table form as above. Measurements, ring counts and ring curvatures should also be included as above. Also include overall flot weight.

Wood

Site name/number	Sample no.	Timber no.	Wood identification	Sample description	Length (mm)	Depth (mm)	Diameter max (mm)	Diameter min (mm)	Ring counts	Split type	Toolmarks	Quality	Growth	Comment	Recommendation
E465	1	6	*Alnus glutinosa* (alder)	Plank/floor of undercroft	110	0	20		40	tangential	No	Good	medium	40 rings	**Discard and or re-bury**
E465	2	7	*Fraxinus excelsior* (ash)	Plank/floor of undercroft	220	0	22		30	tangential	No	Poor	medium	No obvious tooling, degraded	**Discard and or re-bury**
E465	3	8	*Corylus avellana* (hazel)	Brushwood - post	15	0	78		12	unmodified	Roughly pointed at one end	Poor	slow	no sapwood	**Discard and or re-bury**
E465	4	9	*Prunus spinosa* (Blackthorn)	Plank/floor of undercroft	210	0	22		50	radial	No	Good	medium	variable growth: last 24 rings slow, 24-39 rings fast growth	**Discard and or re-bury**
E465	5	10	*Prunus avium/padus* (Cherry)	Plank/floor of undercroft	210	0	20		20	tangential	No	Moderate	medium	32 rings	**Discard and or re-bury**
E465	6	11	Maloideae (apple/pear/hawthorn/mountain ash)	Plank/floor of undercroft	20	4	6		8	radial	Small facets (2 x 1 cm)	Good	medium	Charred at end	**Discard and or re-bury**
E465	7	12	*Quercus* sp. (oak)	Plank/floor of undercroft	230	20	10		26	irregular	No	Poor	fast	Sapwood, iron nail present	**Discard and or re-bury**
E465	8	13	*Alnus glutinosa* (alder)	Post	20.5	0	0.5	5.6	17	half	No	Moderate	very fast	sapwood present, regular growth	**Discard and or re-bury**
E465	9	14	*Fraxinus excelsior* (ash)	Dowel	12.5	0	2.3	1.9	15	shaped	Cylendrical shaped with slightly rounded top	Good	slow	15 rings on 2.3 cm, rounded end	**Conserve, draw and photograph**

1. Taxonomy: All taxon names should be presented by their botanical name (usually Latin; genus/species italicized; family name not italicized) and by their common name (English) in brackets after the botanical name. Anatomical characteristics from wood fragments do not always allow for identification to species level. Several species cannot be separated anatomically and are instead classified as groups of species, genera, sub-families and families. Examples in this table include *Quercus* (identified to indeterminate species level or “sp.”).

2. Headers: The headers in the table above detail the mimimum recording required for wood remains

Insects

Sample No	**1**	**2**	**3**	**Habitat**	**Distribution/Occurrence**
Site No	**Site 1**	**Site 1**	**Site 1**		
Carabidae					
Pterostichus strenuus (Panz.)	4	2	4	Damp woodland, wet grassland, moss	Common
Dysticidae					
Hydroporus spp.	2	8	5	Aquatic habitats	Varied distribution
Hydraenidae					
Hydraena britteni Joy/*riparia* Kug.	5	3	2	Vegetated ponds, stagnant water	Common
Hydrophilidae					
Coleostoma orbiculare (F.)	4	3	3	Marshes, bogs, swamps	Widespread
Anacaena globulus (Payk.)	4	5	3	Sphagnum mosses, shaded woodland	Widespread
Siliphidae					
Phosphuga atrata (L.)	2	1	1	Predator on mollusca, under loose bark, moss	Widespread
Staphylinidae					
Lesteva heeri Fauvel	8	10	6	Reed debris in swamps, bogs, carr woodland	Common
Stenus spp.	4	4	5	Damp localities generally	Varied distribution
Lathrobium spp.	2	4	2	Damp localities generally	Varied distribution
Staphilinus erythropterus L.	-	1	1	Leaf litter, carr woodland	Widely distributed
Scirtidae					
Cyphon spp.	14	3	2	Aquatic habitats	Varied distribution
Scarabaeidae					
Aphodius fimentarius (L.)	2	1	1	Dung, rarely also in rotting vegetation	Widespread
Chrysomelidae					
Plateumaris discolor (Panz.)	6	8	16	Sedge, cotton grass, sphagnum	Local but widespread
Curculionidae					
**Rhyncolus ater* (L.)	-	2	3	In rotten pine, oak primarily	Not known from Ire today / restricted distr. UK
Limnobaris t-album (L.)	1	4	2	On reeds, sedges	Local but widespread
Scolytidae					
**Scolytus mali* (Bech.)	-	-	1	Under bark of various fruit tree species, also elm	Not known from Ire today / Notable B (UK)
Total (MNI)	58	59	57		

1. Order and nomenclature: Family/genera/species of beetles are listed in taxonomic order using nomenclature and known authority (i.e. 'L.' etc.) from the most widely used species list in palaeo/archaeoentomology i.e. Lucht (1987), with updates and modifications by Bohme (2005). Common or colloquial names are generally not listed. Other orders of insects, where they occur, should be listed in taxonomic order using the appropriate species lists.

2. Quantitative vs semi-quantitative counts: The former is essential for all final reports i.e. exact counts of each genus/species per sample should be shown in the table. This means that direct comparisons, including statistical analysis, can be carried out between sites. The latter is acceptable for assessment reports. Any variation to this rule of thumb should be fully explained in the methodology section of the report.

3. Habitat and distribution (occurrence) data: A column showing the known habitat and distribution data for each genus/species of beetle listed should be included. Species that are not currently known from Ireland should be highlighted in the table e.g. by asterix. Habitat data can take the form of abbreviations or codes, but a key to these must be provided at the end of the table.

Pollen

Pollen counts are expressed in a percentage pollen diagram using TILIA 2.0.b.4 (Grimm 1991).

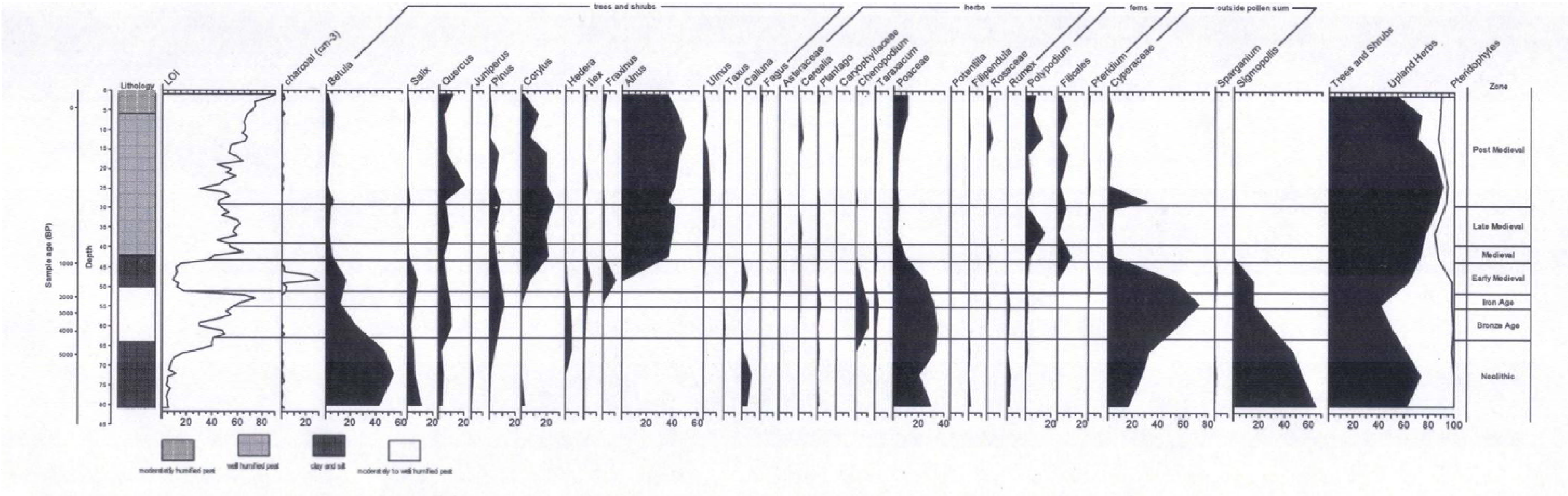

Fig. 22 Example of a percentage pollen diagram. Kilcurley wood, small hollow, Co. Westmeath (Ellen OCarroll)