Chapter 1

Archaeological Reconnaissance

This chapter introduces the key methods used by archaeologists to locate sites and to reveal and investigate the details of known sites without excavation. We have outlined some strengths and limitations of the most important techniques and identified the way in which different techniques are used for locating and investigating sites in particular circumstances. Reconnaissance is developed in other chapters, including Chapter 7 and the Biddenham Loop key study in Chapter 12.

HOW SITES ARE FOUND

Archaeologists use a wide range of reconnaissance techniques to locate new archaeological sites and to investigate known sites without excavating them. Some archaeologists predict that future advances in non-invasive, and non-destructive, methods will see them become a viable alternative to excavation, not least because of the costs of digging. Reconnaissance techniques are also used to map evidence of human activity across a landscape (▶ p. 229). The particular methods chosen will depend on the question being investigated, the terrain and the scale of the study. The time and resources available are also key factors.

Every year hundreds of new sites are located in the UK and many thousands worldwide. Some result from organised landscape surveys or from the discovery of artefacts by metal detectorists or divers. The 2009 Staffordshire Hoard of Anglo-Saxon metalwork is a significant example of the latter. Some sites are spotted from the air or even from satellites in space. Google Earth has proved a valuable tool in finding sites as diverse as coastal fish traps, Roman villas and hundreds of prehistoric tombs in the Arabian Desert. Some of the most important archaeological discoveries have come about completely by chance. The discoveries of the body of Ötzi the Ice Man by skiers and of the Altamira cave art by children are classic examples. A Neolithic tomb at Crantit in Orkney was found when a digger fell through the roof! Farming and industrial extraction processes such as quarrying, dredging and peat cutting all regularly produce finds of material or features. Some named sites which were documented in the past were located by using written sources. Schliemann's discovery of Troy is the classic example but many battlefields and shipwrecks also fall into this category. Of course some archaeological sites were never 'lost' to begin with. Stonehenge and the Pyramids were well known before the development of archaeology. Then there are buildings from the last 200 or more years which are still in use and the traces of our industrial heritage in both urban and rural landscapes.

Most field archaeology in the UK is developer-led and before any project, large or small, planners demand that an archaeological evaluation (▶ p. 573) is carried out to reveal the impact development proposals might have on the historic environment. Such evaluations have the potential to reveal new sites as well as review earlier evidence. Similarly, research excavations will start with an evaluation of what is already known about a site or landscape from existing records. However, reconnaissance should not be seen simply as the precursor to the real business of digging. In some cases sound survey and evaluation is capable of providing all or most of the evidence needed.

There are many reasons for archaeologists to undertake reconnaissance work including evaluations for developers, major university or government projects, amateur local society investigations and students involved in personal studies or as a piece of extended research for a degree or for a post-graduate thesis.

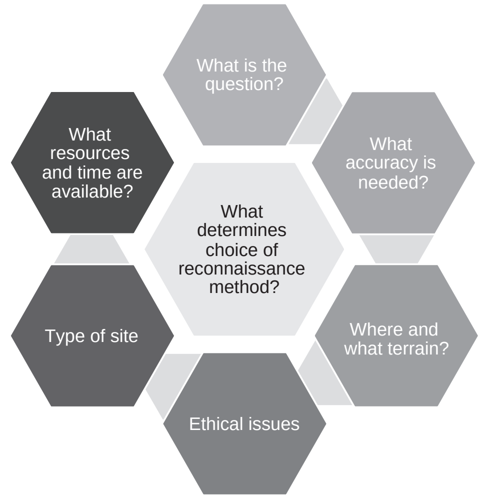


Figure 1.1 *Factors influencing the choice of reconnaissance methods*

Reconnaissance methods

To locate or explore sites during research or ahead of development there are four broad and complementary categories of methods that are commonly used:

- desktop study
- surface survey
- geophysical or geochemical survey
- aerial survey and, increasingly, remote sensing.

Technically speaking an archaeological site can only be discovered once. All subsequent investigations are designed to add information to the initial discovery. Primary methods at the archaeologist's disposal are capable of making that first identification of a new site; for example, aerial photography or fieldwalking. Other methods can be viewed as secondary (in sequence not importance); for example, some geophysical surveys are better suited to developing understanding of details on known sites. However, this distinction is not rigid. 'Primary methods' are also deployed in a secondary context: a site which has been identified from aerial photography may still be investigated later by fieldwalking or vice versa.

A classic case of survey, reconnaissance and targeted excavation can be seen in the pioneering Shapwick Project in Somerset which investigated the development of an estate owned by Glastonbury Abbey. Here a battery of reconnaissance methods including evidence from maps, historical sources and environmental data were combined with limited sampling of deposits through shovel pit testing, geochemical survey and excavation. The results when all sources of evidence were brought together enabled the production of regression maps (▶ p. 8) showing the development of settlement in the area.

DESKTOP STUDY OR 'DESK-BASED ASSESSMENT'

As its name suggests, this is an activity largely conducted indoors using a range of documents and records including those available online. All archaeological research starts here. Some archaeologists, usually concerned with shipwrecks, aircraft crash sites or historical individuals, may gain most of their answers from such sources

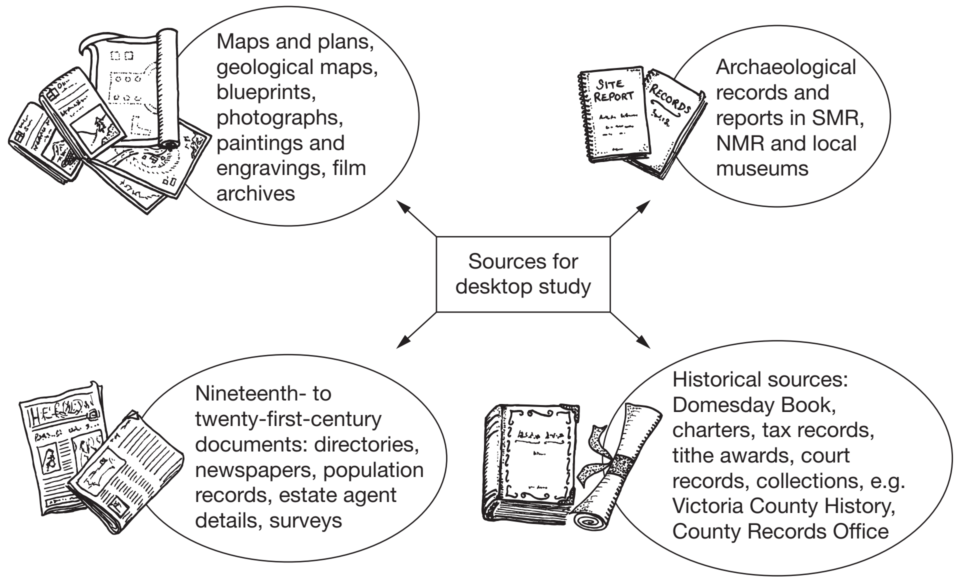


Figure 1.2 *Archive sources commonly used for desktop study*

because there may well be relevant information already capable of answering their question. More commonly archaeologists want to understand what information may be accessible and to interrogate those records as a precursor to fresh investigation. It is quite remarkable how much original research does indeed take place but more often than not it links to earlier finds or discoveries and helps to extend and develop our knowledge and understanding. In some cases desktop work makes fieldwork unnecessary. A recent example was where the Trent and Peak Archaeological Unit was contracted to carry out an evaluation ahead of the new A46 dual carriageway on the Fosse Way in Nottinghamshire. Desktop research enabled them to advise the contractors to avoid two significant Romano-British settlements in favour of a route which only impacted on some minor sites. These were excavated ahead of the road building.

Desktop study involves researching maps and historical or archaeological documents including aerial photographs about the area under investigation. If they are not in private hands, these are most likely to be held in planning departments, county records offices, Historic Environment Records (HERs), local Sites and Monuments Records (SMRs) or the National Monuments Record (NMR) offices. Details of previous archaeological work and records of stray finds for much of Britain are held in local HERs. These records are increasingly digitalised and a national version is being built up at the various NMR offices. Printouts which include lists of earlier research can be made by inputting grid references.

The Portable Antiquities Scheme (PAS) (▶ p. 579) has been in existence since the late 1990s and is moving towards recording 1 million finds. Its website allows archaeologists to search for finds

KEY TERM

Historic Environment Record (HER)

The new name for SMRs. The local authority archive of records and databases covering archaeology and the built environment.

NOTTINGHAMSHIRE SITES AND MONUMENTS RECORD Site No. 03055

Cross-refs. N75174 T4416 OS SW 38
District Newark NGR SK 7350 5125
Parish Fiskerton cum Morton

Precise locations on OS map with 8 figure grid reference

Site Name

Class. Type Round barrow Linear feature
Period General BA Period Specific
Form cropmark excavation

What the site is and how it appears

Site Status Area Status

Description
Circular enclosures, linear features. (1)
Ring ditch, thought to be a barrow, excavated 1975 in advance of development. Situated on a slight knoll on the flood plain terrace, it survived only as a cropmark. The circle is 25.0m in diameter, the flat bottomed ditch 2.0m wide and 70cm deep. 12 sections were made. In the infill, there were layers of iron panning and traces of iron stain in the deposits of natural silts. The only finds were 4 flint waste flakes, and a small fragment of handmade pottery, possibly a fragment of an early BA collared urn or food vessel. No burials were found (destroyed by ploughing?) Looks like a BA barrow (2) See 03055a for adjacent cropmark.

Key information on the site

Descriptive Type
circular enclosure linear feature

Finds
worked flint pottery

Location of finds

Archaeology History (Event, Name, Date, Source)
Full excav, O'Brien C, 1975 (2)

Other material from the site and where it is held or recorded

Sources
No. 1 Type AP Pickering J, 7351/1

No. 2 Type Desc Text TTS, 1979, vol 83, pp 80–2

No. Type

No. Type

No. Type

Written records or accounts of the site

Visits

When the local archaeological service inspected it

Compiled/Revised
24/08/1987 VB

Figure 1.3 *How to read an SMR/HER printout* by date and place. The distribution patterns may primarily reflect the distribution of metal detectorists who report their finds but PAS can still have a role to play in providing a picture of past human activity in an area. Other archives may be found at some universities, archaeological societies, cathedrals, museums and libraries, although these vary widely across the country. Increasingly documents, including archaeological site reports, are being digitised and made available online. A major source of information is English Heritage's website PastScape, which gives easy access to over 400,000 records. Other key resources include the Archaeology Data Service at the University of York and the Heritage Gateway, which provide free online digital resources including searchable databases and many reconnaissance and excavation reports.

Historical documents

A diverse assortment of documents may be of value to the archaeologist. These will vary by county, area and period. In much of the country, known documents are archived or recorded in the County Records Office. In many areas, useful sources have also been catalogued in a volume of the Victoria County History (VCH). Based at the University of London, the VCH has been recording and publishing detailed county and parish histories since 1899 and covers most of England. This is often the first resource researchers turn to.

Type of record	Examples and content	Useful for understanding
Legal documents	Records of ownership, charters or court records of disputes often included physical description of property. Wills and inventories which can be linked to particular buildings may provide lists of contents.	Boundaries and occasionally land use Clues to that building's use
Tax records	Tax surveys, tithe awards and the Domesday Book	Landowning units and the economic uses of land
Economic records	Order and sales books and C19th directories e.g. Kelly's Estate agents' bills	Functions of buildings and industrial archaeology Changes in historic buildings
Pictorial records	Paintings, engravings and photographs Aerial photography archives	Identification of sites and tracing changes to standing buildings and landscapes
Written accounts	Descriptions of places in books, diaries, newspapers and travelogues	The function, construction methods and identity of many sites
Antiquarian records	Reports of early antiquarians such as Stukeley on Avebury	Descriptions of monuments as they were before the modern period
Archaeological journals	National journals such as *Archaeologica*, published by the Society of Antiquaries, go back to the C18th. Many regional or specialist period journals go back to the C19th.	Previous excavations and illustrations and descriptions of artefacts

Figure 1.4 *Historical sources for desktop study*

Only a fraction of early records have survived and those that have need translation and interpretation. Amongst the potential range available, the categories shown in Figure 1.4 are important.

Maps

Maps are amongst the most basic tools and sources used by archaeologists. They are used to locate and explore sites and to answer questions about previous use of the landscape. They are of particular value in tracking changes through time (settlement shape and location, boundaries, land units, fields and hedges). They can also be used to relate sites to geology and topography. Medieval archaeologists are often able to produce their own maps for periods before mapping began. They do this by working back from the oldest available map and cross-referencing historical sources and fieldnames. This technique is known as regression. Medieval fieldnames provide a kind of oral map of the landscape as seen by farmers of that time while post-enclosure fields often refer to nearby features such as woods, mills and lime kilns. Those researching archaeological sites need to be able to use scales, at least six-figure grid references and to 'read' contours and hachures (the marks used to indicate earthworks). They may also use other evidence such as photographs and written accounts to interpret maps and plans. A wide variety of maps are used by archaeologists, including the following.

Early maps

Maps from the C16th tend to show the properties of the rich. They are not always to scale but may

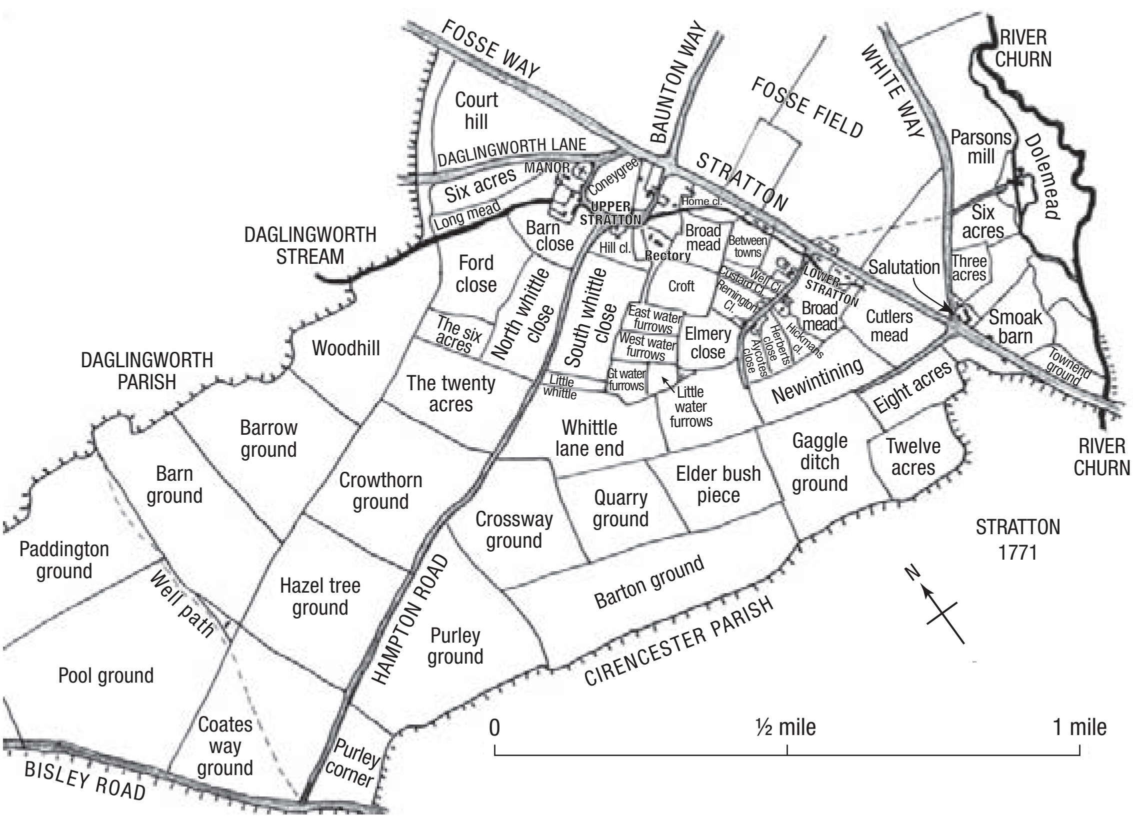


Figure 1.5 *1771 enclosure award map*

provide visual information such as illustrations of specific buildings. John Speed's maps of the early C17th are classics and his town plans are often the first visual records of these sites. From this century too there are route maps such as Ogilvy's Road Book, which is a series of linear strips. Maps were produced to show the proposed routes of turnpikes, canals and railways in order to gain permission from parliament for building to take place.

Changes in rural landownership from the C18th onwards were recorded on enclosure award maps, while taxes owed to the church by landowners were sometimes written on tithe award maps. Sometimes these can be cross-referenced and both can provide information about fieldnames, routes and boundaries, which are vital for landscape archaeology. Other maps show landscaped gardens and battlefields or provide plans of factories and mines. These early maps are often held in county record offices but some may be in private hands or belong to churches.

Ordnance Survey (OS) maps

During the early C19th the OS mapped each county at 1 inch to 1 mile (corresponds to 1:50000 today). From the 1880s OS 6 inch to 1 mile maps (corresponds to 1:10000 today) provided more detail of individual buildings and even hedge species. OS maps established a new standard in accuracy and a comprehensive system of coding and keys for features. A grid system was used which covered the whole country and enabled precise references to be given. By examining a succession of maps for any area,

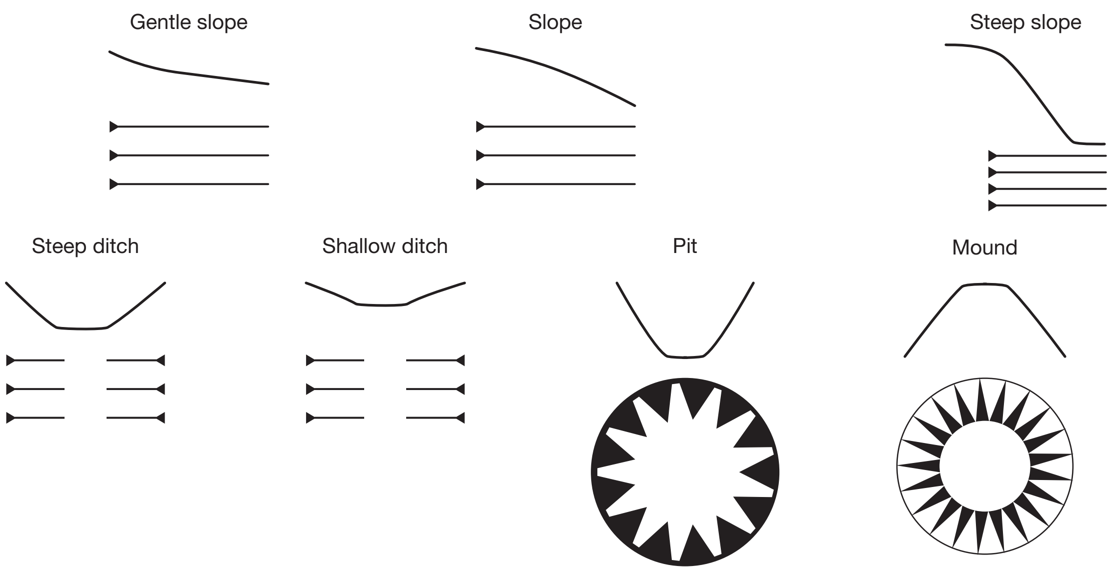


Figure 1.6 *How to read hachures on a map*

Hachures are used on maps and plans to indicate the presence of slopes. Shown wider at the top of a slope and reducing in thickness towards the bottom of the slope they indicate both the steepness and length of the slopes. Short and thick hachures represent a short and steep slope whereas a long and gentle slope is depicted by long and thin hachures. The closer hachures are clustered, the steeper the slope. Some surveyors use elongated triangles or 'T-shapes' while others draw symbols rather like tadpoles where the wider 'head' end can be remembered as being to the top – as in a pond – and the tail wiggles downwards. To read hachures off site plans, learn to look for the thicker ends of the marks which are the tops of slopes so that you can recognise rises and falls in the landscape.

changes in land use and the built environment can be easily seen.

Maps used in archaeological research

The OS 1:25000 series show the location of some archaeological sites but planning maps that use the OS grid system are required for investigations. The 1:10000 (old 6 inch) maps are sometimes the most detailed available for mountainous, remote and some rural areas but 1:2500 (old 25 inch 1 mile) rural or 1:1250 urban planning maps are normally used. For fieldwalking 1:10000 or 1:2500 is used and for excavation the 1:2500 or 1:1250 provides a base. A 1:2500 map allows you to identify individual metre squares with a ten-figure grid reference. These maps are held in county or district planning offices. Copies can be ordered from specialist map shops. Other maps sometimes used include the Geological Survey series, street maps, factory plans, vegetation and climatic maps, land use and classification, soil surveys and specialist archaeological maps. Increasingly archaeologists are using computerised mapping systems based around Geographic Information Systems (**GIS**).

Online versions of maps will increasingly be important. The more powerful of these can incorporate old maps and aerial photographs within national or international grid systems. Google Earth is the best known and its Stonehenge Riverside Project app hints at the potential of this medium but there are many others.

Geographic Information Systems (GIS)

GIS are powerful databases which can store many layers of data against individual map grid references. This can include details of topography,

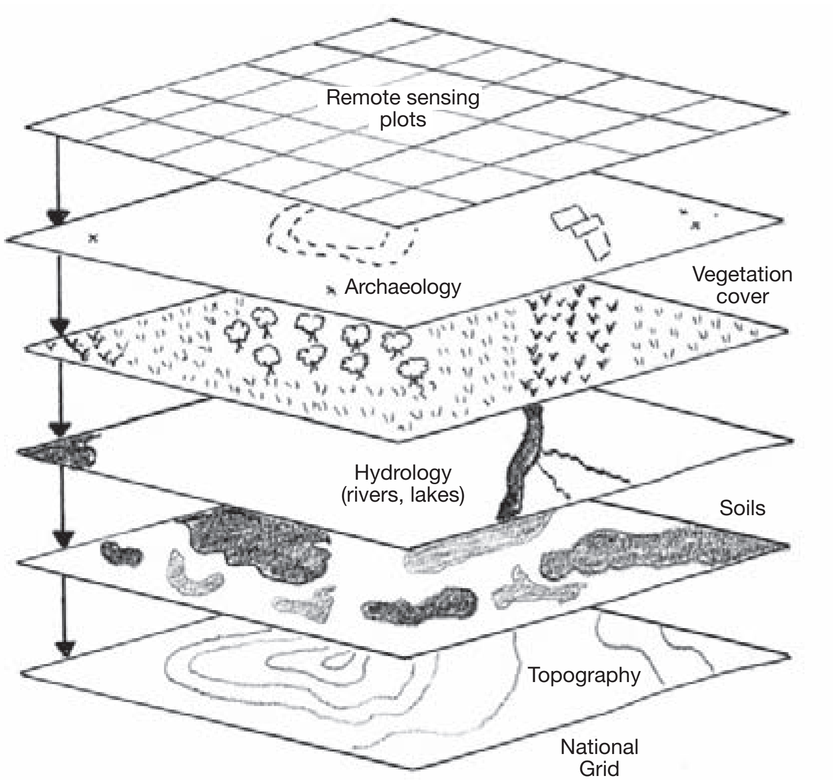


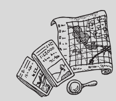
Figure 1.7 *GIS overlays*

geology and vegetation as well as archaeological data. GIS can integrate data from satellites with field recordings. It is revolutionising the recording, presentation and interrogation of archaeological data.

GIS enables direct mapping and recording of data at the excavation site. This allows for immediate access to the data collected for analysis or it can be incorporated with other relevant data sources to help understand the site better. For example, the location of sites can be examined in relation to things like distance to permanent water, changes of slope, extent of view, intervisibility with other sites and contemporary vegetation cover. The southern Hebrides Mesolithic Project (▶ p. 235) used GIS to examine patterns and views from Mesolithic flint scatters and hunting sites on Islay. This 'viewshed approach' enabled them to gain insights into hunting strategies. GIS was used at Castle Hill near Crewkerne in Somerset to establish and map what areas of the landscape were visible from the hilltop and thus to allow discussion on the possible importance of the site in the early medieval period. GIS can produce topographic maps and site plans in three dimensions and perform com-

KEY STUDY

Scottish Coastal Archaeology and the Problem of Erosion (SCAPE)



SCAPE's activities in the area of archaeological reconnaissance highlight how a community approach and professional academic survey can be combined to research and record an aspect of our threatened heritage.

You may be familiar with the Neolithic village of Skara Brae, Orkney (▶ p. 274), and its dramatic exposure following a great storm in 1850. This site is just the most famous of thousands of archaeological sites located close to the sea and subject to its potential destructive effect (▶ p. 569).

Research

To obtain an understanding of the extent of the sea's threat in terms of the number and variety of sites at risk, Historic Scotland began a programme of coastal survey in 1996 and the management of this task passed to SCAPE five years later. SCAPE's aim with the surveys is to search for sites along the foreshore, the coast edge and a strip of land extending back from this some 50m or so. This is a truly monumental task given that the Scottish coastline stretches for approximately 15,000km and as of 2011 only about a third of this has been explored. Within those 5,000km over 12,000 sites have been plotted (an average of 2.4 per kilometre), half of which were previously unrecorded, and about a third of them (3,700) now carry recommendations for further work. SCAPE has a new project which is asking the public to revisit sites with recommendations to check their condition and to help prioritise action at the most threatened. Details of sites are available on an interactive website and an app allows for sites to be recorded in the field using a mobile phone.

SCAPE also manages the Shorewatch Project, which aims to encourage and assist members of local communities to locate, record, monitor and even excavate archaeological sites around Scotland's coasts. Local groups can organise themselves to be on hand to note damage and changes that occur after storms or high tides. Many of these groups have been trained in how to recognise sites and record them using specially designed forms to ensure all relevant information is collected. Detailed planning and surveying often occur as follow-ons from initial recordings.

Figure 1.8 *The SCAPE Project*

Surveying activity in process at Baile Sear next to an exposed hearth. It proved to be the site of an Iron Age wheelhouse. Credit: Ronnie Mckenzie / The SCAPE Trust

Investigations

As in any reconnaissance situation, a small number of key sites are subsequently investigated thoroughly. In the case of Shorewatch local teams work in collaboration with professional archaeologists as at Baile Sear, North Uist. Here an Iron Age settlement was exposed in 2005 and accurate plans were drawn at intervals as the team monitored its gradual erosion over the following months. This was followed up by a full excavation at two of the wheelhouses, locating walls almost 2m high and uncovering many pits within the buildings containing thousands of sherds of pottery, burnt animal bones and some human remains. At a second site at Boddin in Angus, C18th lime kilns were threatened by collapse so a laser scanner was used to provide a digital recording of the monument backed up by photography and desktop historical research.

The fieldwork element of SCAPE's work is complemented by other archaeological survey methods. When the Coastal Zone Assessment Survey of the coast of Angus north of Dundee was undertaken in 2009 the first phase was a full desk-based assessment, using information from the Sites and Monuments Record, Aberdeen and the National Monuments Record (held by the RCAHMS). Old maps, historical texts and excavation reports were also checked, together with aerial photographs. The information was added to a database and plotted onto maps using GIS. The second phase was completed by surveyors walking the entire route.

SCAPE's website provides access to a wealth of information as to how this Trust and the Shorewatch Project pursue their aims to record Scotland's eroding past.

plex statistical analyses. It can even be used to predict site locations based on known patterns (▶ p. 247).

Several other related computer tools which are proving useful to archaeologists are often lumped together with GIS. These include computer cartography, 3D rendering and computer animation. These techniques are especially useful for creating accurate maps and digital terrain models (DTM) which allow the archaeologists to view sites and data in both two and three dimensions.

Oral accounts

People are an important resource for archaeologists. Farmers and others who work on the land or within the built environment could have valuable information for archaeologists who may lack local knowledge. Interviews with people provide clues as to the use and development of recent buildings. Farmers, for example, may be able to identify areas where building rubble has been ploughed up or where dressed stones have been removed. Sometimes estate management records may hold this information for earlier periods. Fishermen or divers can often provide insights about underwater sites (▶ p. 309).

SURFACE SURVEYS

This term can be used to encompass fieldwalking, surveying and even planned aerial photography. We will concentrate on non-destructive visual surveys at ground level. These can range from slow, painstaking searches on foot to quite rapid examinations of a landscape from a vehicle looking for upstanding earthworks. Since most sites lack visible features, the former is more common. Fieldwalking is often concerned with finding traces of unrecorded sites, though it can be used as a follow-up to aerial photography to ascertain the potential chronological period of, say, a cropmark site. Scatters of building rubble or artefacts or slight undulations in the surface can reveal where there may be buried walls or house platforms. Differences in soil or vegetation may also be indicative of past human activity. For studies of the Mesolithic and Neolithic in Britain, scatters of flint and animal bone are often the only traces of human activity visible in the landscape. To study the activities of these mobile populations, careful identification and plotting of these scatters is essential. Surveys can also encompass the study of hedges and woodlands for traces of past economic activities and to help locate settlement areas (▶ p. 243). Surface surveys can cover large areas such as Webster and Sanders' work in the Copan Valley of Mexico or coastal areas in the Scotland's First Settlers project (▶ p. 235).

Waddington's (1999) study of hunter-gatherer exploitation of the landscape in the Milfield basin of Northumberland combined several reconnaissance methods with some limited invasive techniques. He identified five ecozones in the basin from gravel terraces around the River Till to sandstone uplands and studied a transect across them. In arable areas he was able to use fieldwalking but in pasture areas he used shovel pit testing (▶ p. 23). Patterns of finds were used to construct a model of land use. This suggested settlement was largely on the gravel terraces where wetland resources could be exploited. However, task groups (▶ p. 232) travelled to the uplands to hunt deer and gather wood and other resources. His study was also valuable in understanding why finds are more likely in some areas than others. Sediment coring revealed the way in which soil slip and build up affected buried archaeology and the way in which erosion in one particular area of peat was leading to more finds of lithics than in other areas and thus distorting the overall pattern of finds.

Surveying features

Surface investigations of known sites include micro-contour surveys of the topography. These detailed studies involve the precise use of

surveying tools to build up a picture of variations in height and levels. Micro-contour surveys often reveal hidden features that could not be detected with the naked eye. In most studies, the areas to be surveyed are measured using surveying equipment or Global Positioning Systems (**GPS**) and are set out with rows or squares of pegs, cane or marker poles. This is to enable accurate sampling and recording. Data from surveys can be loaded into digital terrain modelling (DTM) software to create 3D images of the landscape and features within it. It can also be combined with other data such as that from geophysics. Most professional surveys will use a total station. This combines sighting lens, level, laser measuring and an on-board computer to calculate angles and distances. More sophisticated models include GPS.

Figure 1.9 *Using a total station*

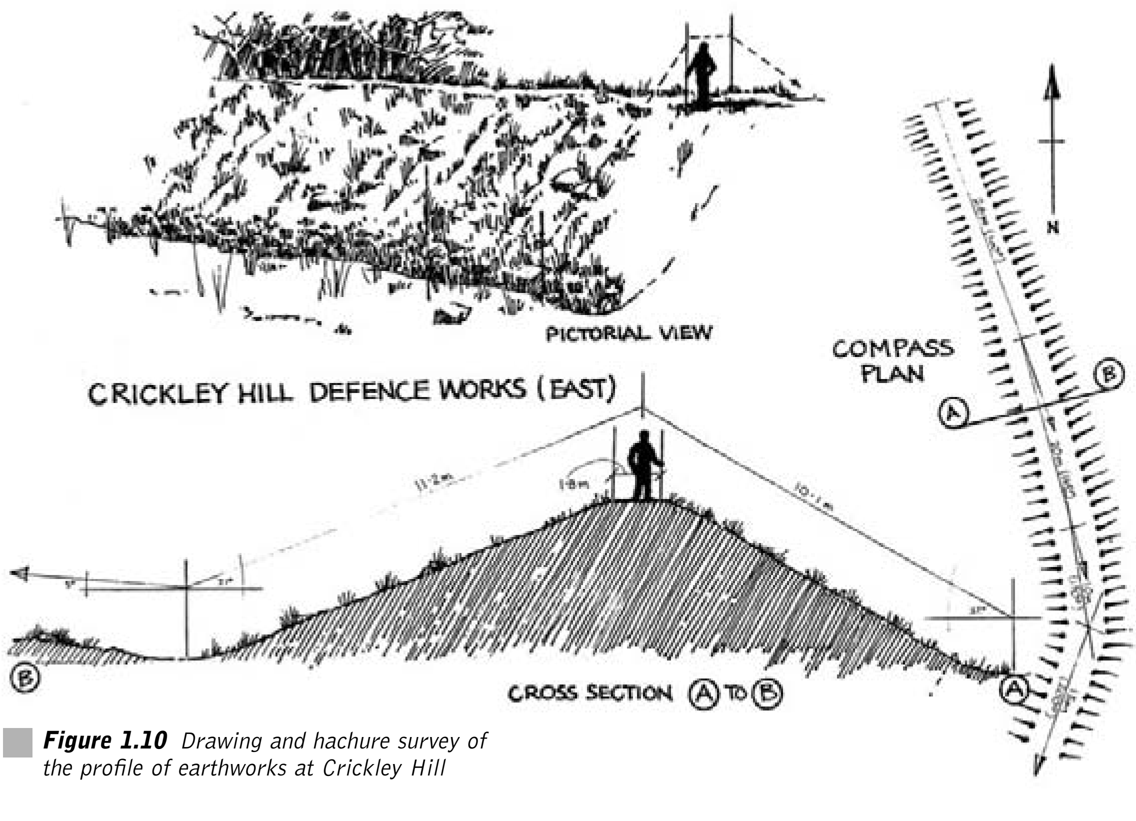


Figure 1.10 *Drawing and hachure survey of the profile of earthworks at Crickley Hill*

Another long-standing method of manual survey is known as plane table survey. This is a much more complex approach and requires a wider range of equipment and understanding. The plane table is levelled and orientated and an alidade (a sighting device) used to observe the key points of a site. A tape is used to measure from alidade to point and both distances and angles recorded as a series of 'rays' from the plane table. The English Heritage pamphlet *With Alidade and Tape* (2002) provides a detailed description of what is needed and how the various pieces of equipment can be used in combination to achieve the best results. An even simpler alternative where precision is not essential or for a rapid survey of a large site is to use pacing and compass directions to measure linear features. Clinometers,

Figure 1.11 *A simple earthwork survey using tapes, poles and clinometer*

KEY STUDY

Surveying an abandoned landscape on St Kilda

This joint survey project between the Royal Commission on the Ancient and Historical Monuments of Scotland (RCAHMS) and the National Trust for Scotland aimed to evaluate the current state of the archaeological remains on the four main islands of the St Kilda archipelago, and to identify, map and record them systematically. These remote islands are 40 miles west of the Outer Hebrides and were continuously inhabited for over 2,000 years until the population was evacuated in 1930.

Much had been written about various aspects of life on St Kilda, but it quickly became apparent that the locations of the archaeological sites were largely unmapped. This seemed all the more amazing given that St Kilda is a Mixed World Heritage Site (▶ p. 577) in recognition of both its natural and its cultural heritage. What was previously known depended on local knowledge and some sketches of features plotted in the 1970s onto copies of the OS maps, plus the results of an RCAHMS survey in the 1980s and the work of a PhD student. To remedy this shortfall in the record, the project team adopted a methodology that combined the use of GPS survey equipment with high-definition ortho-rectified (geometrically corrected to remove distortions) aerial photography.

On the main island, Hirta, archaeologists mapped in detail a landscape with the most recent settlement (evacuated 1930) comprising cottages with strips of land running back from the seashore

continued

to the 'head-dyke' – the boundary that divided agricultural land from rough grazing. On the seaward side of the head-dyke just over one hundred cleits had been recorded, and at least another 1,200 have now been plotted across the rest of the island. Cleits are small multipurpose drystone structures which were originally roofed with stone and turf and are unique to St Kilda. They were used for drying and storing seabirds, eggs, peat and crops. The date range of the cleits is not known, but desk-based research shows some marked on a C17th map as 'pyramids' while late C19th photographs show that others cannot have been built until the early C20th. Field boundaries predating the head-dyke were also observed, though some of these features had been planned in the 1980s RCAHMS survey and through a study by archaeologist Mary Harman. Recording the cleits comprehensively for the first time demonstrated how much more information can be teased out with a fresh pair of eyes.

The most remote of the four main islands is Boreray. Archaeologists and other visitors had previously noted cleits and bothies (small basic dwellings or shelters), plus linear features which had been interpreted as channels to collect water. Reference had also been made to a 'wheel-house'-type structure, suggesting much earlier occupation – perhaps prehistoric. In 2010 fieldworkers spent a week on Boreray. The majority of the archaeological remains lie on a south-west facing grassy slope that plunges steeply into the sea. What had previously been considered as water channels were now better interpreted as field boundaries, and a hitherto unsuspected complex field system was revealed, stretching across the slope and incorporating cultivation terraces, garden plots and lazy beds (a form of spade dug cultivation that looks a bit like ridge and furrow).

Figure 1.12 *Survey work on St Kilda. Note the GPS staff held on the left*

It became clear as work progressed that the cleits and bothies on Boreray consistently overlay the banks and terraces, thus revealing a relative chronology (▶ p. 145), with the field-system earthworks clearly the earliest. The discovery of three settlement mounds added complexity to this sequence, though field observation alone could not establish a direct relationship between the mounds and the field system. Of the mounds, some contained elements of internal structures: these could be interpreted as prehistoric, but equally might date to the 1st millennium AD. Detailed surveys such as the one on Boreray challenged old ideas and revealed entirely new interpretations of the apparently inhospitable landscape; a most unlikely place to settle.

Data and pictures from this survey are available online from the Royal Commission on the Ancient and Historic Monuments of Scotland website which provides another example of a large, free archaeological database.

tape and ranging poles can be used to estimate heights and the lengths and angle of slopes.

Recording standing buildings

One specialised area of archaeological surveying focuses on the built environment and links archaeology to architectural science. Detailed studies of the material and construction techniques of structures are made both to enhance knowledge of the development of buildings and to provide a record against future destruction or decay. Laser scanning is used in some buildings which are covered with lichen to see how they are constructed. Records will range from written description to CAD (computer aided design)-based recording of every brick or stone. Most recording of buildings occurs as part of the planning process (▶ p. 572) or during conservation work. Two examples are the Defence of Britain project, which collected records on surviving defensive monuments of the Second World War, and Sutton Scarsdale Hall, an English Heritage site near Chesterfield in Derbyshire where site evaluation, geophysics and architectural survey were combined to record this large but derelict property. The recording of standing buildings is covered in Chapter 2 (▶ p. 77).

Sampling in archaeological fieldwork

Whatever is deposited is a fragment of past material culture. Dependent upon the material, a variable portion of these deposits will survive. Archaeologists will recover a sample of these. Not every site can be fieldwalked, let alone excavated. Choices have to be made. If these choices are arbitrary (non-probabilistic) they could lead to bias in the **archaeological record** with certain types of evidence being neglected and others over-represented. For example, if archaeologists chose only to study hillforts from the Iron Age or, as often happens, if development only led to excavation in one part of a town, it might create an unrepresentative picture of life in the past.

When archaeologists design reconnaissance or excavation research strategies, they use a rigorous form of probabilistic sampling to reduce bias in recovery. This means that the chance of anything being recovered is known. First, the plan of the total area or site to be surveyed is divided up either into a grid pattern of numbered squares or a series of equidistant parallel lines or transects (▶ p. 21). Both are usually aligned north–south to link into the national survey grid, although sometimes grids in fields are aligned on a particular boundary. With large areas it is common to select a sample of grids and then use transects within them. The scale varies according to the task. An initial surface survey of a whole

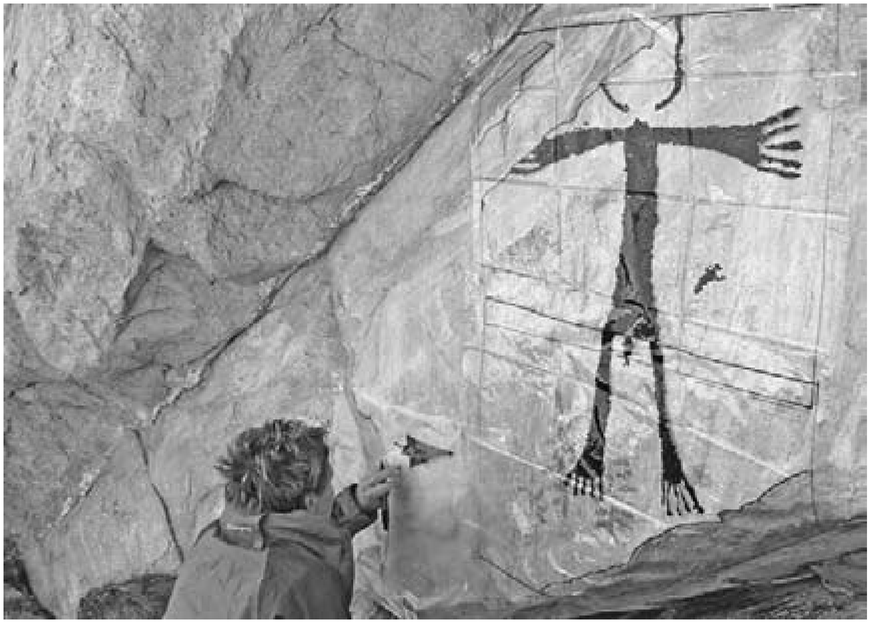


Figure 1.13 *Rock art survey using GPS and GIS*

The survey of rock carvings or petroglyphs illustrates many aspects of reconnaissance and recording techniques. In addition to a detailed record of each petroglyph being made by tracing and photographing at this site near Valcamonica in Italy, the position of each petroglyph is identified by GPS. Its height above sea level and orientation are also measured and the information entered into a GIS database. This enables 3D presentations to permit the study of relationships between petroglyphs and topography or between each other.

landscape might start with 100m or km squares and then have transects between 10 and 50m apart depending on terrain and resources. For test pitting on a known site, the initial grid might be 1m square. You need to understand four basic approaches to sampling. Our illustration is for grids but the principles are the same for transects.

A simple *random sample* (A) works like a lottery. The numbered units are selected by computer or number table. This is fair as each unit has an equal chance of being selected, but it can also lead to clustering and thus miss features.

Stratified sampling (B) overcomes clustering bias by first dividing the sample universe into sections. For example, if the site has natural zones such as hills, valley and plain, then numbers are selected randomly for each zone in proportion to its area.

Systematic sampling (C) overcomes clustering by selecting at evenly spaced intervals; for example, every third grid or every 10m. This ensures a more even selection although it could miss things that are regularly distributed. It usually requires a higher number of samples.

Stratified systematic sampling combines the last two methods and could be used to take more samples in particular zones than others.

FIELDWALKING

Fieldwalking, or surface collection, involves the systematic collection from the ploughsoil of artefacts which might be indicative of human settlement. This is based on the reasoning that material on the surface reflects buried remains. Sometimes high-density scatters of particular

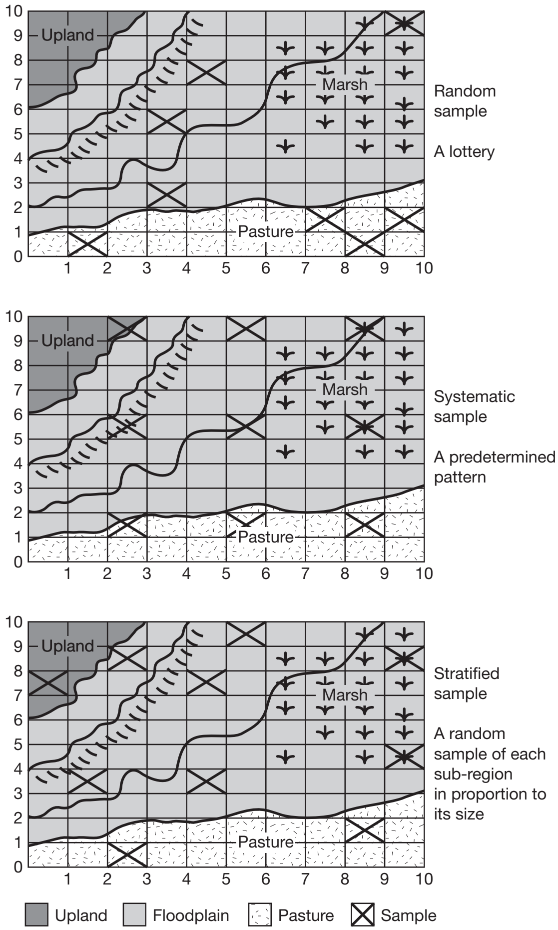


Figure 1.14 *Models of different approaches to sampling*

materials such as building rubble or broken pottery enable specific sites such as buildings or kilns to be identified. More typically, the method helps identify locations of past settlement or activities such as hunting. Ceramics and worked stone are the most commonly gathered materials but metal, bone and burnt stone are often also collected. The method is destructive in that archaeological material is removed, but as it has been disturbed by ploughing, it is not in its original context anyway.

Decisions about sampling have to be made when planning fieldwalking. Not everything will be collected, particularly when building rubble is involved. For instance, will all ceramics be collected or just diagnostic pieces or those over a certain size? Decisions also have to be taken about the width of transects or size of grids.

These are linked via a base point to the national mapping grid. Sometimes the fieldwalk plan will align with the national grid but boundaries and other features in the landscape may make this impractical. In order to link site grid to national grid and to establish the height above sea level of the site, theodolites have traditionally been used. In the UK these enable visual links to be made to Ordnance Survey benchmarks. Benchmarks were established nationwide on existing features such as bridges or on stone or concrete pillars to provide a system for the accurate calculation of levels linking back to the Ordnance Datum at Newlyn (ODN), Cornwall. Most benchmarks are of the 'cut' variety with a horizontal line (for which the height relative to ODN is given in the records) above an incised arrow. The Ordnance Survey's website allows a search by OS kilometre square which provides an instant list with notes and eight-figure grid references to enable location of benchmarks in any area. With the correct equipment the benchmarks are a valid source for levelling but are probably more of historical interest allowing another route to exploring the historic environment's record. They were a vital part of any surveyor's toolkit until the use of Global Positioning Systems (GPS) superseded them. Although about 500,000 still survive, their number is decreasing as a result of development and removal of their original sites. The Ordnance Survey no longer maintains them. The Royal Institute of Chartered Surveyors and the Ordnance Survey have jointly produced a leaflet entitled 'Virtually Level' which offers a clear explanation of the change from benchmarks to GPS.

Timing is important. Ideally ploughed soil should have been broken down by weathering and recent rain will have cleared dust from the surface. Walkers either proceed along a transect

Figure 1.15 *Fieldwalk finds from a Roman site*

in a series of stints or search a grid. These are carefully set out with marker flags or poles. Grids are slower to walk and tend to be used when total coverage of a field is required. The material collected is bagged and tagged with the number of the grid or stint for processing and analysis. Once washed and identified by specialists, finds are counted for each grid or stint. They can then be plotted on a distribution map to show patterns and concentrations. There are many ways of displaying this information. Phase maps or a series of clear plastic overlays for each period or type of find are commonly used. Computer displays using GIS have an edge here since several types of data can be linked to any point and comparisons easily made.

Fieldwalking is a well-established method because it has many strengths. It is a relatively cheap way of surveying large areas since volunteer labour can be used to collect and wash

Figure 1.16 *Ordnance Survey benchmark*

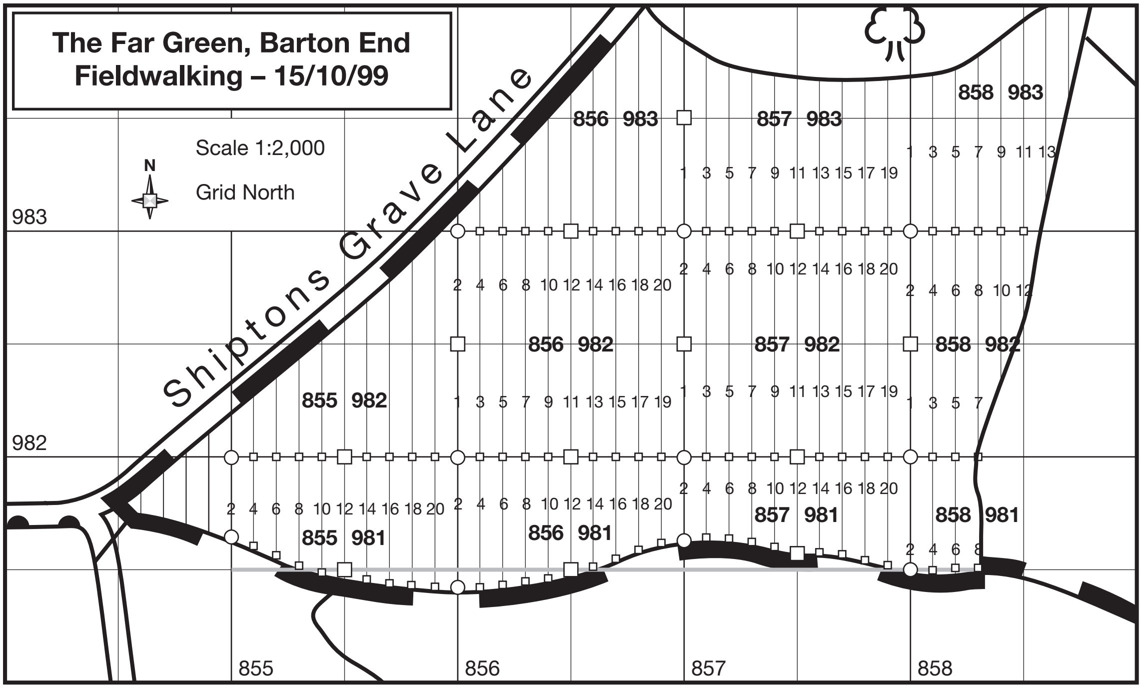


Figure 1.17 *A planned fieldwalk which has been linked to the national grid system. Transects are 10m apart with 50m stints.*

KEY TERM

Transects, traverses and stints

A **transect** is a sampling line which could be across a single site or an entire landscape. It is usually aligned north–south and tied into the national grid. In fieldwalking, transects are usually divided up into manageable chunks or stints of 10 to 50m where one walker will use one collecting bag. 'Traverse' is a term used largely in geophysics and sometimes aerial photography to describe the straight, parallel paths passed over by the surveyor. So a magnetometer survey might use traverses set at 0.5m apart.

finds. It can help establish the function and period of a site without excavation and provide insights into location and exchange. Consideration does need to be given to time and effort. For example, to completely cover even a relatively small field (100m x 100m) an individual would walk 50 x 2m stints each 100m long – the equivalent of 5km – on ploughed soil! Better to find four friends!

Limitations of fieldwalking

Fieldwalking can indicate the spread and foci of evidence. It does, however, have important limitations too. It is only really useful on arable land and then only at certain times in the agricultural cycle. In addition, its results cannot always be taken at face value as, for example, medieval manuring practices may have transferred much domestic refuse to the ploughsoil thus hinting at sites that simply do not exist.

Figure 1.18 *Fieldwalking in progress. The experience and training of fieldwalkers and the conditions on the day all affect what is recovered.*

As with other survey methods, further research is always needed to substantiate preliminary findings. Chris Gerrard's work on the Shapwick Project sheds additional light on the limitations of fieldwalking. Different materials were found to behave differently in the same soil. Repeated walking of the same fields and monitoring ceramics in them showed that some material migrated further than others. Patterns for pottery from different periods were also very different. It was not always a good indication of settlement. A second variable was the differential collection by different fieldwalkers. Analysis of their finds showed that some were good at recognising and collecting one type of material but poor with another. This applied to experienced walkers as well as novices. Their performance varied according to weather and slope. Taken together it means that what is recovered is a sample of what was in the topsoil and the topsoil holds a sample of what lies below. In both cases the sample varies for each type of find. Fieldwalking results therefore need to be cross-checked with other data before conclusions can be drawn.

Alternatives to fieldwalking

There are a number of other prospection methods which provide alternatives to fieldwalking although all are potentially more destructive. **Shovel pit testing** can take place in woods, pasture and gardens where fieldwalking is impossible. This approach to sampling is very common in the USA. Only the top few centimetres are sampled. In each sample a standard volume of soil is sieved through a fine mesh for ecofacts and artefacts. Recent examples of test pitting in the UK are at Kibworth, Leicestershire, where the work was coordinated by Michael Wood for the BBC and in villages around Cambridge by Carenza Lewis.

Coring and **augering** are also used to sample the subsoil. This can provide a snapshot of the stratigraphy and the sample can be examined for artefactual or environmental evidence. An auger is driven or screwed into the ground. It extracts a sample of the subsoil in much the same way as an apple corer. It has been widely used in south-east Europe to detect building horizons. **Probing**, which involves pushing a rod into the ground, is more useful for tracing shallow buried features such as walls on known sites (▶ p. 355). This method proved the simplest and cheapest form of plotting the route of the Fosse Way Roman road and its side ditches across grassland in Leicestershire. Although allowing for a degree of subjectivity on behalf of the person with the probe, traverses across the proposed line of the road were undertaken with the probe inserted at 0.5m intervals and decisions made as to whether

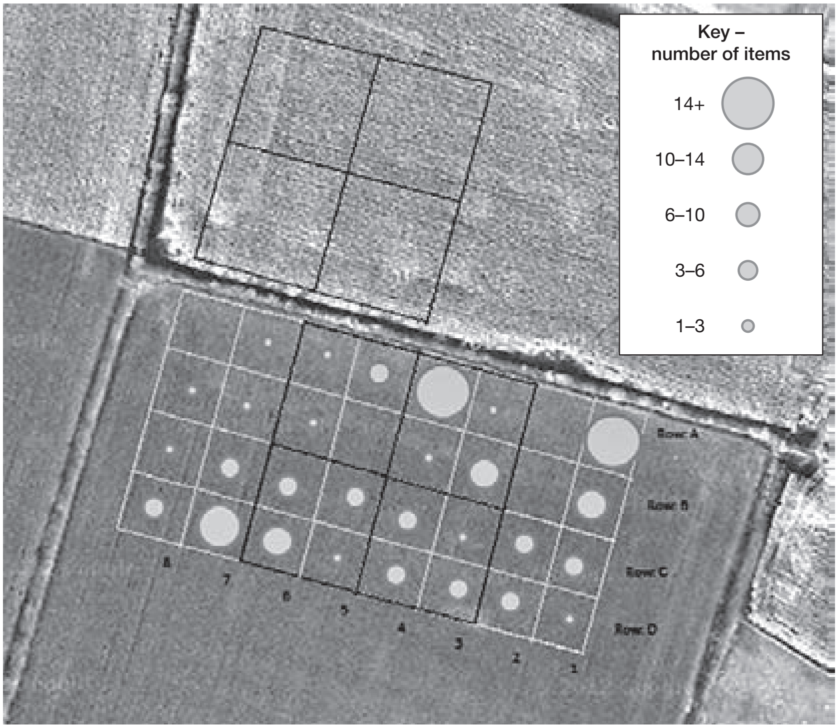


Figure 1.19
The density of Roman pottery plotted in relation to each stint. Amounts of selected materials can also be shown with shapes or dots where the size and colour or shading represent the numbers of finds.

Figure 1.20
Shovel pit testing and dry sieving at Bodie Ghost Town

Figure 1.21 *Probing for stone field boundaries buried under peat at the Ceide Fields (▶ p. 355)*

the probe hit stony ground ('road'), softer fill ('ditch') or standard substrata (between ditch and road or indeterminate readings). The resultant plots showed the road's course (plotted in red), the two ditches (plotted in blue) and other 'responses' (plotted in pencil). Simple but effective and cheap!

Geochemical prospection

These relatively new methods and expensive techniques attempt to locate areas of past human activity by detecting differences in the chemical properties of the soil. All living things produce organic phosphate as waste or through decay. Unlike phosphate in modern fertiliser, this remains in the soil where it was deposited. Where settlement is suspected from other methods such as fieldwalking, samples of soil are taken and levels of phosphate measured in a laboratory. Once plotted, concentrations of organic phosphate may indicate settlements or animal enclosures since this is where most deposition would be expected. Similar principles apply to heavy minerals such as lead and cadmium and to lipids (fats). These techniques may become increasingly important in the future. One possibility is that different chemical combinations could identify 'signatures' (▶ p. 176) for different activities.

GEOPHYSICAL SURVEYS

Perhaps the most noted development in field archaeology over recent times has been the increasing ability to 'see below the ground' using modern technology. With a shift in emphasis amongst archaeologists in favour of preservation in situ rather than excavation, these techniques are now commonplace.

In the UK, the *Time Team* programmes have highlighted the use of 'geofizz' as an almost essential element in an archaeologist's armoury. Given that they usually start with the topsoil intact (and three days to reach a conclusion), some guide as to where to excavate is essential to avoid wasted time and energy and so geophysical methods are quickly combined with other survey methods. Television viewers could be forgiven for thinking that no excavation can operate without a geophysical survey. This is not true. Geophysics is established as a major part of archaeological research and prospecting but the need for it is not universal; for example, where all topsoil has been stripped down to the top of the 'natural' prior to sand and gravel extraction features can be identified by eye in the traditional way (▶ p. 51).

'Geophysics' covers techniques that detect features through their physical differences from the surrounding soil. The most common techniques detect magnetic and electrical anomalies and require considerable skill to interpret. Nearly all these techniques were by-products of military inventions developed to assist bombing or detect hidden locations. Given the heavy investment in research for defence purposes, further new technologies are to be expected.

Resistivity survey

This involves passing an electric current through the ground and noting differences in the ability of the subsoil to conduct electricity. Electricity is conducted through the soil by mineral salts contained in water. The more moisture there is, the better the conductivity of the soil. A buried ditch or grave will generally retain water better than the surrounding soil. A buried wall or road will conduct poorly and therefore resist the current more than the surrounding soil. Electrical current flows close to the surface so it can be measured using shallow probes. Meters are usually mounted on a 'zimmer-like' frame and have a data logger on board to record results. The method works better with some soils than others. Clay retains moisture well so differences in resistance between the soil and buried ditches or pits may be impossible to detect. This also applies to many soils if they become waterlogged in wintertime. Plants, rocks and variations in the depths of soils can also create misleading readings. While relatively easy to use, resistivity meters are not fast and are best suited to detailed exploration of a site or a possible site, located

Figure 1.22 *Resistivity surveying*

RESISTIVITY

The resistivity meter works by detecting anomalies (differences) in the ability of subsurface remains to conduct electricity compared with the surrounding soil.

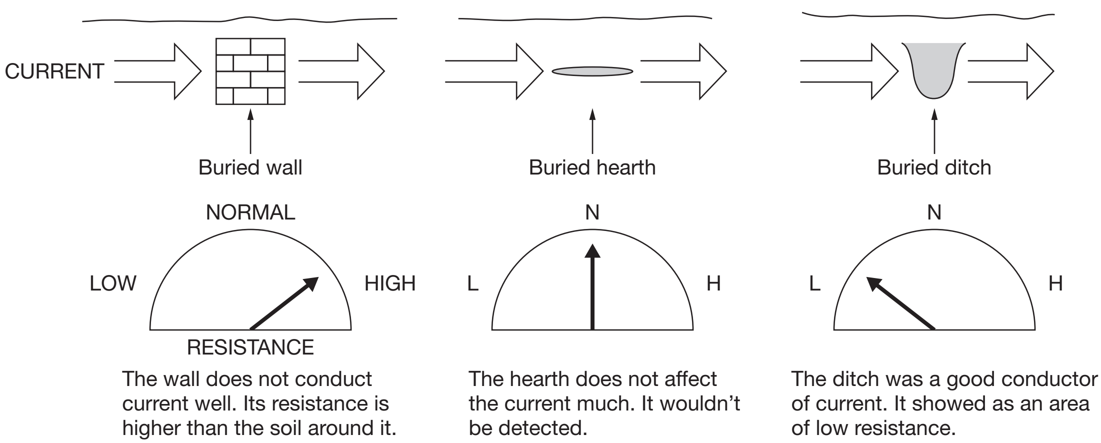


Figure 1.23 *A simplified diagram illustrating the principles of resistivity*

through surface finds or aerial photography, rather than initial prospecting.

Resistivity can also be used to create pseudo-sections of buried linear features. This involves taking a series of readings from a line of probes placed across a buried feature such as a ditch. Increasing the spacing between probes, rather than using narrowly spaced probes, can produce data on the deeper parts of a feature. The depth to which this technology penetrates the soil is limited and readings require considerable interpretation, as the sensitivity of the meters is not great. At Hindwell in Wales, a feature interpreted from the resistivity survey as a 4m wide ditch turned out after excavation to be a series of massive postholes with construction ramps.

Magnetometer surveying

The earth's magnetic field is generally uniform in any one place. However, local magnetic distortions can be caused by past human activity. Topsoil contains haematite (Fe_2O_3), an iron oxide. In some forms its crystals are magnetic. A ditch which has filled up with topsoil will contain more haematite than the surrounding area. Its fill will therefore be slightly different magnetically and this difference may be detected by sensitive, modern magnetometers. A second type of distortion is caused where topsoil has been subject to considerable heat. This erases the magnetic properties of the iron oxides. For haematite, heating to 675°C is required. When the soil cools, the iron oxides become permanently magnetised according to the polarity of the earth's magnetic field at that time. Since this field changes over time, the sites of kilns and hearths appear as magnetic anomalies.

The earliest magnetometers were cumbersome and slow to use. The manufacture of increasingly reliable instruments for archaeology has seen magnetometry become a standard technique. Handheld fluxgate gradiometers, sometimes using twin sensors a metre apart, enable the technique to be used to rapidly scan quite large areas of soil, grass and crops to highlight anomalies. Magnetometers are also used in detailed site investigations where they can detect small features up to 1m down and provide images of some buried features. For very detailed work, traverses are set 0.5m apart with samples every 0.5m. Gaps and sample intervals of 1m are more common.

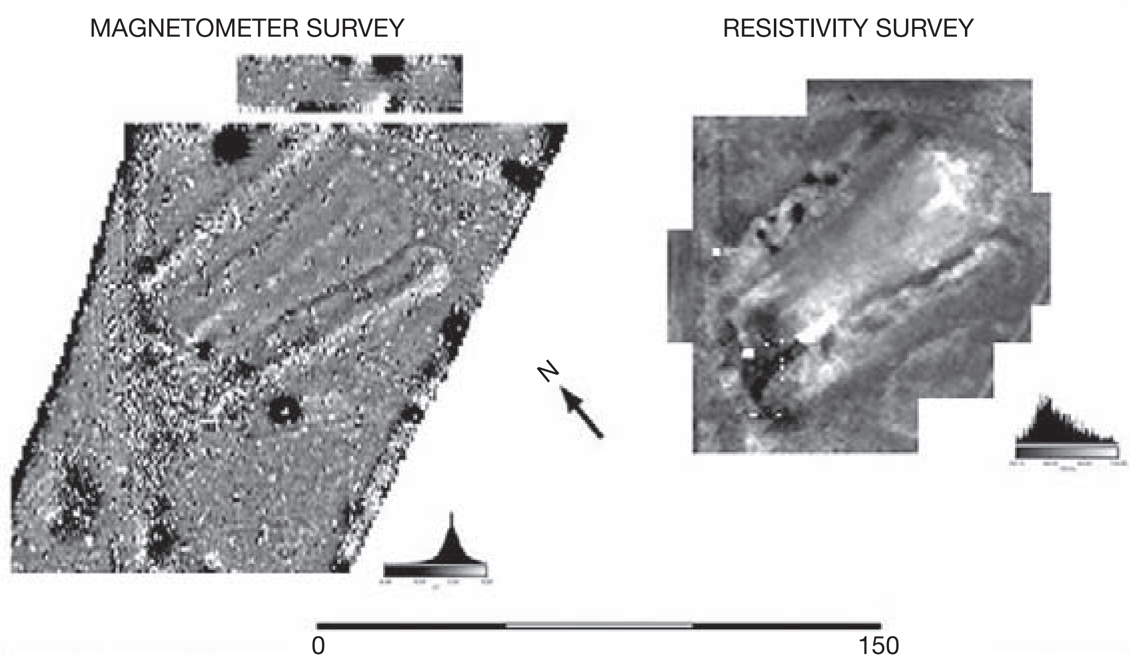


Figure 1.24 *Resistivity and magnetometer plots compared. The essential complementary nature of these techniques can be seen in these plots from English Heritage's survey of White Barrow.*

To be able to detect anomalies, the magnetic background of the soil has to be measured and magnetometers calibrated against it. The measuring of this magnetic susceptibility of the topsoil can also be used as a crude but rapid survey technique in its own right. Magnetic hotspots suggest areas of past settlement or industrial activity, which could be surveyed using other methods.

Sensitive magnetic instruments are easily disturbed by iron, including nails, pipes and wire fences as well as the zips and piercings worn by archaeologists. A further limitation can be background interference from magnetic bedrock or where a long period of occupation has left a magnetic layer over a wide area. Sandy and clay soils often do not provide sufficient contrast. Fluctuations in the earth's magnetic field also have to be taken into account. Data can be quickly downloaded to a laptop in the field but it requires considerable skill and experience to interpret the results.

Magnetometers are also capable of performing on underwater sites.

Caesium vapour (CV) magnetometers

These are many times more sensitive than conventional magnetometers and are more commonly used in Germany and Austria. Typically several machines are used close together on a large wooden handcart. They work by pumping caesium vapour and taking rapid measurements at around 25cm intervals. This alkali is so sensitive to minute variations in magnetism that it can detect and define the edges of buried features formed by traces of magnetite. This iron oxide (Fe_3O_4) is concentrated in the remains of the bacteria which consumed the wooden structures such as posts which once stood there. It has been used at a number of well-documented sites to reveal more of their secrets. Work at Stanton Drew stone circle in Somerset revealed the 'ghosts' of hundreds of postholes in concentric circles. Caesium magnetometers suffer less from the background 'noise' which occurs with handheld devices but at £40,000 per machine and perhaps four machines on a cart, this technique is expensive.

Marine versions of caesium magnetometers are towed behind ships and measure variations in the earth's magnetic field. They can detect ferrous material on or under the seabed.

Other non-invasive methods

Metal detectors are useful for metal objects down to about 15cm. Some archaeologists use them on site to provide information in advance of digging, such as the position of burial deposits. Skill is required to avoid time being wasted exploring buried slag or modern metal debris. Similarly they can sweep areas in advance of detailed geophysics to identify concentrations of metal that might distort readings; for example, on battlefield sites. Danish museums routinely work with local metal detectorists to recover and record metalwork from the ploughsoil around sites and to identify where metal finds are likely to be made prior to excavation (▶ p. 443). This enables the lead archaeologist to check that the diggers did not miss any small finds. Issues around metal detecting are explored in Chapter 12.

Ground penetrating radar (GPR), which was developed for defence and engineering, is increasingly used in urban areas where deposits are often deeply buried and where pipes and cables hamper other geophysics methods. GPR works by transmitting pulses of energy into the ground and

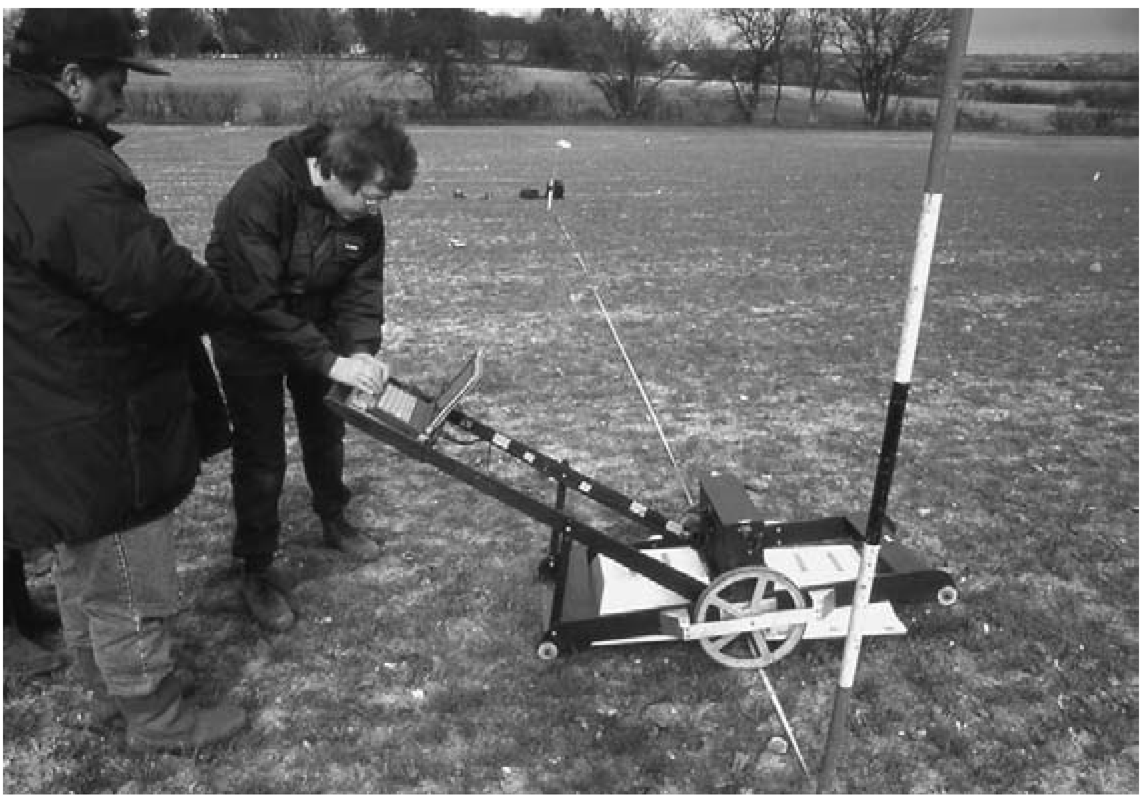


Figure 1.25 *Handcart mounted GPR*

recording the time taken by and strength of the return signal. This can indicate the density and depth of buried deposits. Data based on different energy wavelengths can be plotted as a series of 'time slices' to build up a 3D picture of buried remains. A team at the Bronze Age site of Gordion in Turkey has used GPR as an alternative to excavation and has mapped buried features such as tombs so that they can be protected. More routinely, GPR is useful for detecting buried floors, voids and walls. It has been particularly effective in revealing the internal structures of buildings and exploring burials. It is the only effective geophysics technique in urban centres where it can even penetrate tarmac. Due to its cost and the availability of quicker methods, it has not been used widely outside urban areas in the UK although this is starting to change. The Anglo-Saxon Hall at Lyminge in Kent was discovered using GPR. GPR works poorly on clay soils.

Combining geophysics techniques at Binchester Fort

The Roman fort lies next to the point where Dere Street, the Roman road running north from York to Corbridge, crossed the River Wear in County Durham. Although the site has been known about and in part researched and excavated since the early C19th, it was only when detailed geophysical surveys were undertaken between 2004 and 2011 that a comprehensive understanding of the scale and complexity of the site's features became possible. The original, large timber fort (*c*. AD 75–80) of 7.5 hectares had been abandoned and replaced by a stone fort of 4 hectares in the middle of the C2nd. The underlying features, including ditches from the two forts, shown as marks on aerial photographs taken in the 1940s, were clarified by the geophysics and the *vicus* (civilian settlement) that surrounds the fort was shown to extend to an impressive 12 hectares.

Binchester is a good example of where the three major elements of geophysical survey – resistivity, magetometry and GPR – have been combined to provide the quality and quantity of survey evidence to underpin informed decision making on how best to excavate this 'research' site. A Geoscan resistance meter and a fluxgate gradiometer together provided data to compile a plan of probable features such as roads, ditches and structures. Magnetic data had suggested that the *vicus* was protected in part by a ditch in later Roman times and what appeared to be small, square stone structures were located just outside this ditch. GPR was then focused on these structures and revealed at least two mausolea and part of a third at the edge of the surveyed grid. *Time Team* subsequently based their trench location on this data and were able to recover the physical evidence of the features in their excavation just where the geophysics had predicted. However, a later geophysics survey by ASUD (Archaeological Services University of Durham) provided corrections to their interpretation of the sequence. Binchester is a good example of community engagement (▶ p. 583). The excavation team is led by Durham County Council, Durham and Stanford universities and the local archaeological society. Members of the public can pay to take part.

AERIAL PHOTOGRAPHY

The first aerial photographs (APs) were taken from hot-air balloons. Today, most photographs are taken from light aircraft, although kites, balloons, radio-controlled helicopters or very long poles have been used on occasions. APs can support both archaeological reconnaissance and analysis. Comparatively large areas can be covered in the search for evidence or 'marks'. In some circumstances these lead to initial site discovery while in others they enable more comprehensive investigation of known sites. Aerial photographers devise schedules to ensure that they have the best opportunities for seeing sites and recording them. It involves planning and research to ensure the best possible conditions

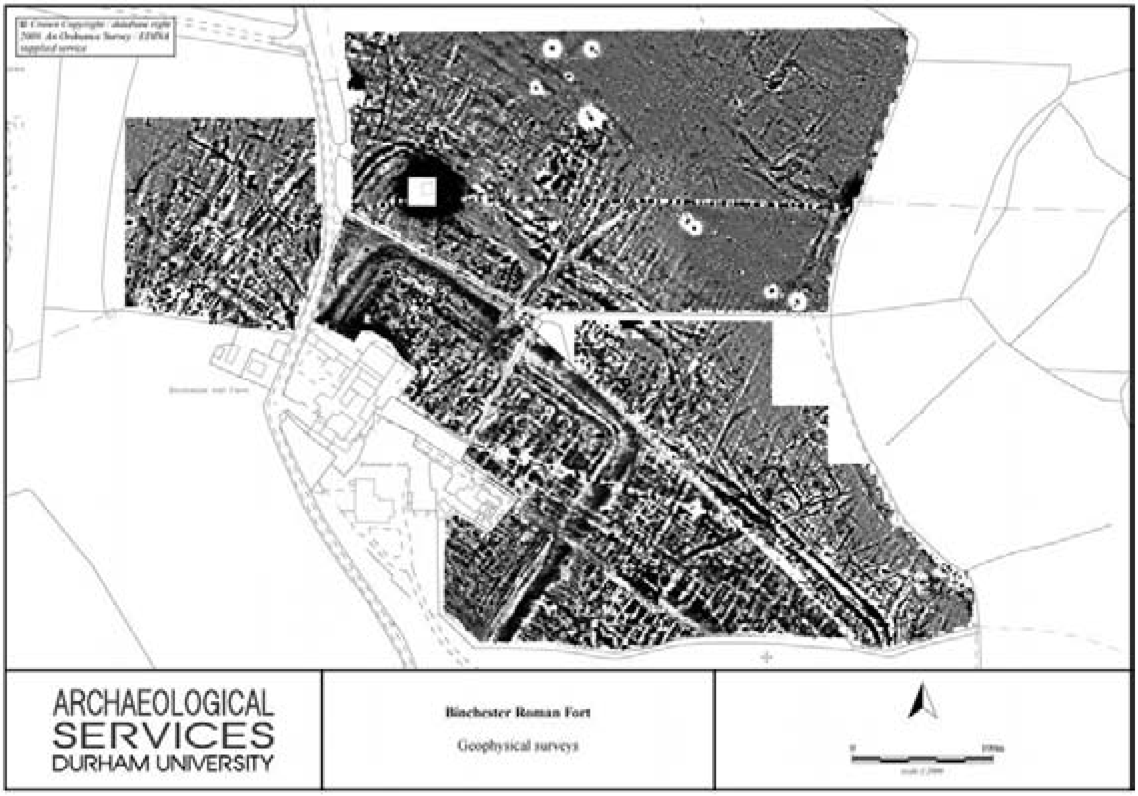


Figure 1.26 *Survey interpretation from Binchester. Excavation sequences blended with the latest geophysics. (ASUD)*

in terms of seasons, weather patterns and agricultural activities. Aerial photographs can aid mapmaking but the main focus here is on reconnaissance and the following paragraphs reflect how different 'marks' can be located and interpreted as archaeological features or sites. It is important to remember that most archaeological sites cannot be detected from the air and that interpretation for all but the most obvious examples requires skill and experience. In particular, interpreters rely on recognising repeated patterns or 'signatures' based on previously investigated sites. Substantial archives of aerial photographs are available publicly and commercially so new research should be based on adding to the current base rather than repeating it at considerable cost. Archives include the impressive Cambridge University collections built up by Professor J. K. St Joseph, the national archive at the NMR, Swindon and regional collections such as the South Yorkshire collection built up by Derek Riley and others.

Aerial photographs used for mapping are taken with the camera pointing straight down at the ground (*verticals*) with the aircraft flying along grid lines. Often these are taken from high altitude and are black and white to maximise contrast. This is the case with the RAF archives dating from the 1940s which are now housed at the NMR. Unless clouds intervene, features can usually be seen clearly and they provide an excellent desktop source for initial study of landscape developments. Usually photographs are taken in an overlapping series so that they can be viewed through a stereoscope to see the landscape in 3D. Their main value is in planning

Figure 1.27 *An aerial photograph of Downton deserted medieval village in Northamptonshire using shadows and highlights to reveal the earthworks. The shadows cast by the trees can be used to establish the position of the sun and thus allow for interpretation of the ups and downs in the landscape. In terms of relative chronology, a later canal cuts through the remains of the village.*

and illustrating sites. Because of the angle of photograph, there is no distortion at the centre of these photographs although some occurs towards the edges. Where some dimensions in the photograph are known, reasonably accurate plans can be drawn of sites, including their contours. This is known as photogrammetric mapping.

Oblique photographs are more widely used in archaeology to reveal sites and features. These are taken from low-flying aircraft with the picture taken at an angle to the ground. Aerial reconnaissance often precedes field survey as it can quickly provide evidence of sites invisible to archaeologists at ground level or add clarity and pattern to those that can be seen; for example, low earthworks which would otherwise require hours of basic field survey and recording.

There are three main types of 'mark' by which archaeological sites show up from the air.

Shadow marks

In low light, either at the start or end of the day, shadows are at their longest and strongest. This means that even quite minor variations in ground level will cast shadows on slopes away from the sun and reflect highlights on up-slopes facing the sun. Careful study of such photographs – once the sun's direction has been established – can reveal sites such as almost ploughed out barrows, the remains of early field systems or hut circles within the interior of an Iron Age hillfort. In an interesting but rather less frequent scenario, shadows are also created where crops have grown to different heights (▶ p. 33) as a result of subsurface features and some new sites have been detected as a result of this phenomenon. Winter is the best season for shadow photography as the sun is particularly low and vegetation which might mask sites has often died down. Snowfall and flooding can accentuate the appearance of hollows and earthworks and create some of the most dramatic images of **shadow sites**. This technique is most frequently used to illustrate and investigate known sites.

Cropmarks

The ripening and growth rate of crops is related to the amount of moisture their root systems can access. Plants, particularly cereals, with better access to moisture will often grow taller and ripen at a slower rate than those plants around them, thus exhibiting a different tone or colour. Conversely, plants growing over, say, a buried wall are likely to be more stunted and ripen sooner. If there are buried archaeological features under a field, this can result in patterns showing in the crop. It is the contrast between unripe (when most of the crop is in this state) and ripened crops –

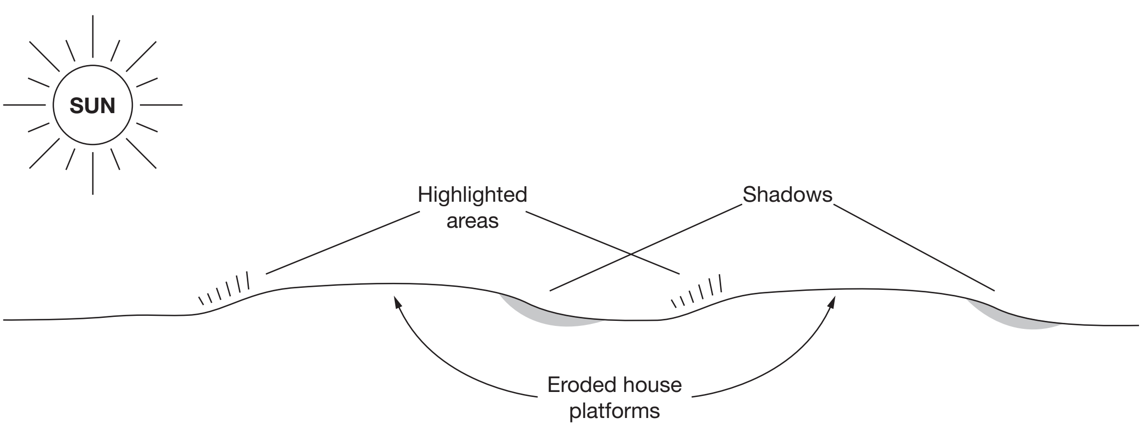


Figure 1.28 *Why earthworks are visible as 'shadow sites'*

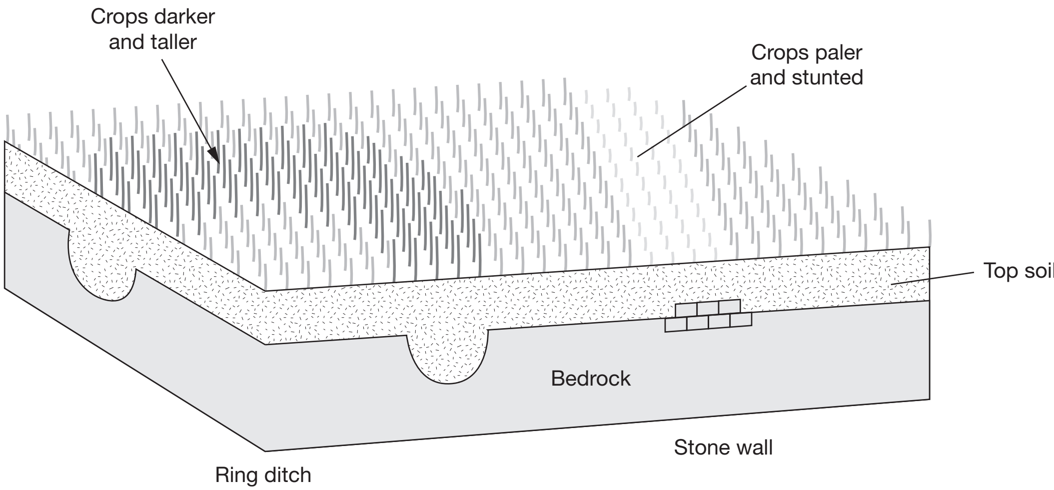


Figure 1.29 *Three-dimensional cross-section of cropmarks*

negative cropmarks – which reveals plans of buildings or routes of Roman roads and the contrast between ripened crop (when most of the crop is in this state) and unripened crop – positive cropmarks – which shows up buried ditches. 'Parch marks' show on grass as negative marks and can often be seen revealing hidden walls under English Heritage's manicured grass at monastic sites.

Cropmarks sometimes only show for a few days a year. Repeatedly flying over areas over time can pick up new and different features. Some only show up in drought conditions when crops with access to moisture have the greatest advantage and colour contrast is exaggerated. The technique works best on fast draining soils such as river gravels but is less good on clay or areas with deep topsoil, where the soil retains moisture well. Major studies have been undertaken along both the Upper Thames and the Trent Valley (sand and gravel zone) based on cropmark evidence of settlements from the Iron Age and Romano-British periods. When the known marks are transferred onto modern maps, the density of earlier evidence shows how intense the settlement patterns were. Cropmarks show up best in cereal crops such as wheat and particularly barley. They do not show up in many other crops – for example, peas and beans – and the effect of differential moisture can be overcome or masked by irrigation or fertiliser. Care has to be taken with interpretation, as geological features such as periglacial cracks and modern field drainage and underground pipelines also create cropmarks. Trial excavation is often the only way to firmly identify many sites. Cropmarks are the most prolific source of new sites, particularly for the late Neolithic to early medieval periods, and are also used to investigate existing sites such as the extent of the harbour at Fishbourne Palace. The lost Roman city of Altinum, near Venice, was extensively photographed in 2009 and sophisticated examination of the cropmarks has revealed remarkable details of the town plan. Italian archaeologists intend to build on their current research using Lidar (▶ p. 37).

Soil marks

On freshly ploughed soils where there is a marked contrast between the colour of the topsoil and subsoil, evidence of ploughed-out monuments can occur as **soil marks**. On chalk, the dark brown of ditch infill will contrast with the chalk

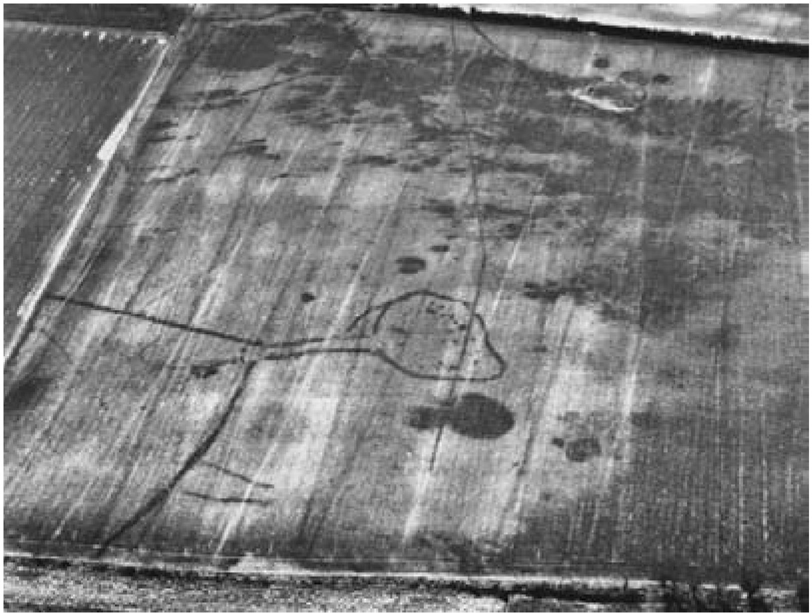


Figure 1.30 *An Iron Age 'banjo' enclosure on Cranborne Chase showing as a dark cropmark. The crops growing over the ditches of the feature are darker because their roots have better access to moisture than the surrounding crops. (Crown Copyright 1955 and 1959/MOD)*

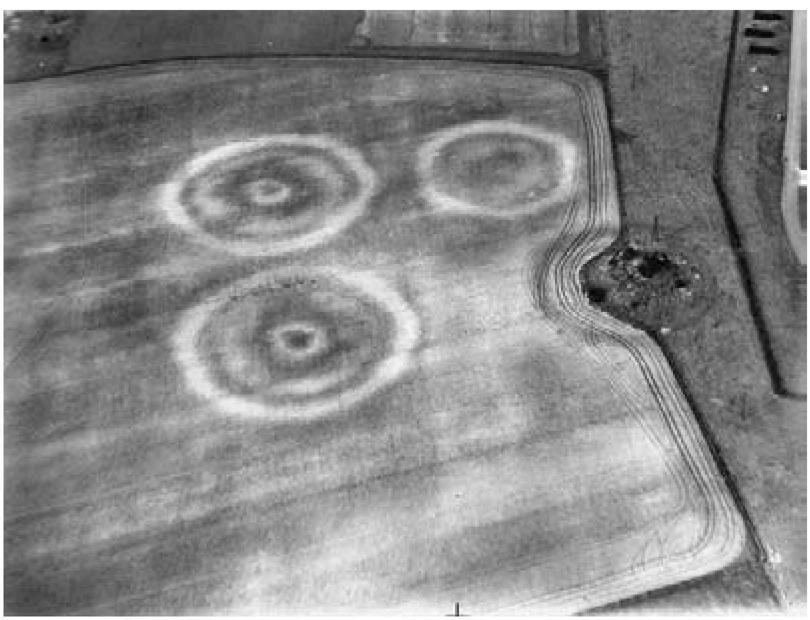


Figure 1.31 *Winterbourne Stoke round barrow cemetery showing as soil marks. The difference in tone between the topsoil and the material used for the barrow provides a clear contrast. The monuments would not be easily detected on the ground. (Crown Copyright 1955 and 1959/MOD)*

KEY STUDY

Contrasting approaches: Empingham and East Kent Access Road

This key study dates back to the early 1970s when plans were drawn up to build a dam across a small river valley and thus create a large reservoir now known as Rutland Water. It highlights the combination of many of the survey methods described in this chapter and the extent to which they contributed to the discovery of the various archaeological sites. Finally a contrast is made with the methodology behind the reconnaissance for sites along the route of the East Kent Access Road on the Isle of Thanet in 2010.

Empingham

The first indication of interest was when a farmer showed an Anglo-Saxon brooch he had ploughed up to a local archaeologist – an early form of the Portable Antiquities Scheme. The fact that such finds are usually associated with burials led to an exploratory excavation (now called 'evaluation') which when extended eventually revealed a small inhumation cemetery of fourteen burials. Conversations over coffee during the dig included issues of how sites can be found and fieldwalking and its potential contribution was raised. The farmer then took the archaeologists onto an adjacent field where they picked up a quantity of Romano-British pottery. An excavation later uncovered a farmstead (aisled barn, well, buildings and farmyard) at this location.

The planned dam and reservoir works constituted a 'threat' in Department of the Environment (now English Heritage) speak and grants were made to enable excavation to progress, though this was limited mainly to the summer season. Part of the area was under pasture (the fields along the River Gwash itself) while arable farming was practised further back up the valley slopes. No shadow or crop marks were visible on the aerial photographs available and mapwork showed only a medieval moated site in the village itself some 500m from the Anglo-Saxon and Romano-British sites. However, the presence of archaeologists working in the area brought in information from other farmers, and trial trenching (▶ p. 56) with a JCB in a field across the river but directly opposite the farmstead revealed a second Romano-British site which was subsequently excavated and shown to be a simple 'villa'.

At this point, as construction work on the dam began, Anglian Water, the consultant engineers and the earth-moving teams all readily accepted the need for a watching brief (▶ p. 575) during the work as an area of almost 1km^2 was scraped off by heavy plant machinery. Careful observation of these exposed surfaces over a period of three years revealed traces of an Iron Age settlement, two more significant Romano-British farmsteads, some Anglo-Saxon huts and a second much larger Anglo-Saxon cemetery with 133 inhumations and a single cremation. All these sites were investigated but the major excavation was of the AS cemetery where immediate salvage work had to take place. The excavators employed the services of a metal detector under controlled circumstances to give initial indications of grave locations. The Department of the Environment's geophysics team used a fluxgate gradiometer to see if magnetic anomalies could show outlying graves and the ditch which formed the cemetery's western boundary.

Modern approaches

In the modern scenario the earliest stages of the Empingham story might well be repeated but plans for such significant engineering works would today require a major archaeological assessment

continued

Figure 1.32 *Excavation of Grave 5 Empingham*

(▶ p. 573) and evaluation. Anglian Water would be required to fund this and react to and support any necessary archaeological research and fieldwork. Whether the survey methods of today's professional archaeological contractors would have fared better cannot be stated but the overall activity and presence would be far greater than the ad hoc situation that prevailed in the 1970s.

The 2010 dig on the East Kent Access Road on the Isle of Thanet studied 48 hectares (about half the area stripped for the works at Empingham) over a nine-month period, moving directly to a substantial investigation – a big dig – rather than spend time on extensive field evaluation. While the features and finds on the Kent excavation far exceeded the Empingham record, it is noteworthy that much of the material evidence was once again revealed during top-stripping overseen by a resident team of archaeologists.

rubble of a bank and the lighter brown of the ploughsoil. At Flag Fen, a Roman road appeared as an orangey stripe against the black peat soil.

REMOTE SENSING

This can be a rather confusing term. Usually it is used to distinguish between the imaging techniques used from planes and satellites and those of ground-based prospection. This may or may not include aerial photography. Sometimes it is used to describe all techniques that do not remove material. When you come across it, be sure to check which sense it is being used in. We are using it in the first sense. The results of all these techniques need to be checked at ground level.

Most methods work by recording radiation in the form of light reflected from the earth's surface. Tiny differences at the surface in terms of vegetation, minerals, water, loose or packed soil, texture or temperature all impact on that reflected light. Only a small range of wavelengths within the electromagnetic light spectrum are visible to the human eye (visible light). Infrared and ultraviolet light are invisible. The development of sensors to 'see' these other wavelengths and computers able to analyse them was originally intended for military use but offers huge potential to archaeology. The earliest development was colour infrared film, which was used to detect hidden installations and tanks during the Second World War. It was subsequently used to detect buried archaeology from slight differences in vegetation.

Airborne and satellite techniques, including thermal imaging and infrared photography, are able to record temperature, dew and frost dispersal variations invisible to light-sensitive film. They all work on the principle that anomalies such as disturbed earth, ditches or buried walls will absorb and retain heat or moisture at different rates to the surrounding ground. These can be identified from differences in colour on screen or printouts. Computers can be programmed to search for particular types of anomaly. Remote sensing can be particularly valuable when exploring large or inaccessible areas.

Cost means that it is not used in most surveys while commercial equipment is really only suitable for large features because each pixel has a side of up to 30m. However, one can anticipate that increases in sensitivity from military purposes will eventually filter through to satellites which prospect for minerals or monitor glaciers and these in turn will benefit archaeology. An example is the discovery of hundreds of buried tombs (including seventeen pyramids) through

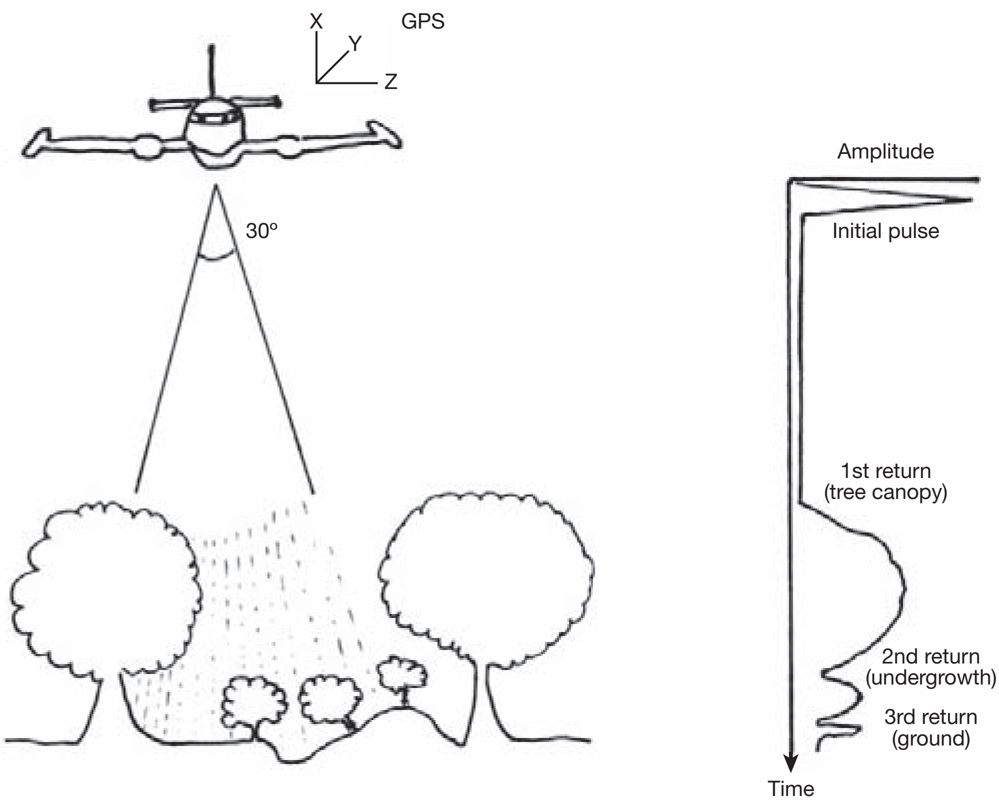


Figure 1.33 *How LiDAR works*

Figure 1.34 Earthworks at Welshbury before LiDAR survey. Very little is visible through the trees. (Crown Copyright. Courtesy of Forest Research, based on Unit for Landscape Modelling data. www.forestry.gov.uk/fr/lidar)

Figure 1.35 *Earthworks at Welshbury after LiDAR survey. The vegetation layer has been digitally removed to reveal the lost landscape. (Crown Copyright. Courtesy of Forest Research, based on Unit for Landscape Modelling data. www.forestry.gov.uk/fr/lidar)*

infrared satellite images by a University of Alabama team at Tanis in Egypt.

Satellite survey

The rediscovery of the lost city of Ubar, a key trading point for camel trains carrying frankincense across the Arabian desert from the Bronze Age to around AD 300, illustrates the potential of remote sensing. Historic records suggested the town lay in a vast area of sand dunes known as the empty quarter. Radar images from NASA's space shuttle failed to locate the city because it was buried too deeply. Thermal and infrared imaging from the Landsat and SPOT satellites was more successful. These can detect minute differences in the earth's surface and present them as colour differences for analysis. Reddish streaks indicated several routes which differed from the surrounding desert by having fewer rocks, more dust and soil enriched with camel dung (Blom et al. 1997). These converged on the village of Shisr. Archaeological investigation revealed artefacts from as far away as Greece and Rome, which testified to its likely importance in long-distance trade. Further examples of the use of remote sensing are explored in Chapter 7.

Lidar

Experimentation with the use of lasers in meteorology led to the development of a number of techniques involving light to provide highly accurate images of objects or surfaces. Lidar (Light Detection and Ranging) uses lasers mounted in a light aircraft to transmit 400 pulses per second of scanning laser beams which are reflected back from the ground surface and recorded on sensors. The time taken for light to bounce back determines the precise distance from the aircraft. This method records differences every 10cm across the survey area and is far more sensitive to tiny variations in terrain than conventional photographs of shadow marks. Beams bounce back from both the top of vegetation and the ground surface. This means it can penetrate forest canopies while the time difference between the readings enables the height of vegetation to be calculated. This has been particularly useful in surveys of Mayan sites in the jungles of Belize. Lidar can be used seamlessly over land and sea to a depth of around 50m. When mapping the seabed it is known as Bathymetric Lidar.

Sonar

Sonar (Sound Navigation and Ranging) was developed to detect submarines and is a form of acoustic sensing. It uses pulses of sound waves to locate objects underwater. For archaeology, side-scan sonar is used to map the topography of the seabed. Usually a 'tow-fish' containing the sonar transmitters is towed behind a survey vessel and emits a fan of acoustic pulses on either side. A sound signal or echo is reflected back and recorded. Raised or protruding features have a strong return and appear as light areas while shadow areas have little or no return. This enables continuous virtual photographs of the seabed to be made relatively quickly. High-resolution sonar can be used to create virtual photographs of submerged objects. The online Museum of Underwater Archaeology provides a wealth of information and case studies on marine surveys.

EXPLORING LOST LANDSCAPES

The value of reconnaissance techniques in revealing new archaeological information is evident in recent studies of the seabed around the UK. Archaeological reconnaissance and records of stray finds have been combined with data from oil-exploration companies. High-resolution bathymetry uses lasers to record and provide images of seabed topography. The use of 3D seismic research records sound waves 'bouncing' back off the seabed from low frequency pulses generated by airguns. This reveals the geological nature of the seabed. Coring and grab sampling provide data on sediments including environmental

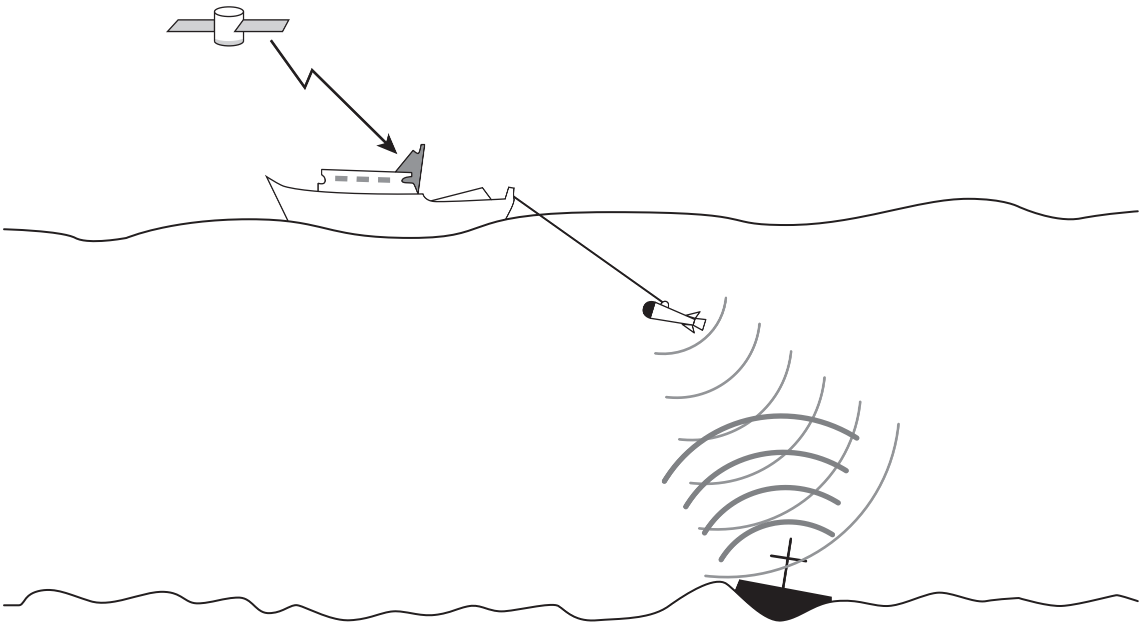


Figure 1.36 *How side-scan sonar works*

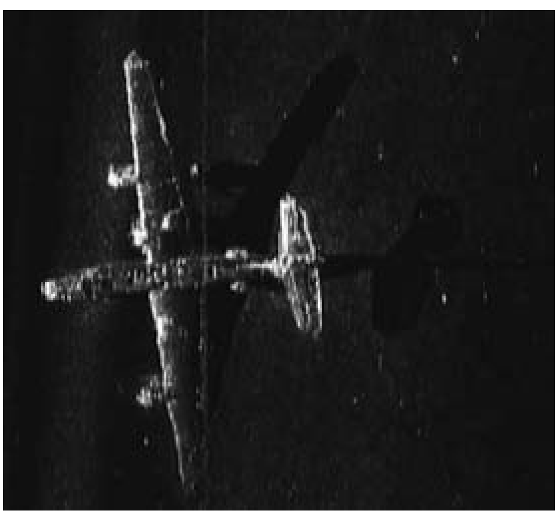


Figure 1.37 *Side-scan sonar image of a submerged aircraft. This US Navy PB4Y-2 Bomber was recorded by high-resolution sonar mounted in a tow-fish device. The aircraft is at the bottom of Lake Washington in the USA under 164 feet of water. (Picture courtesy of Marine Sonic Ltd)*

Figure 1.38 *Doggerland*

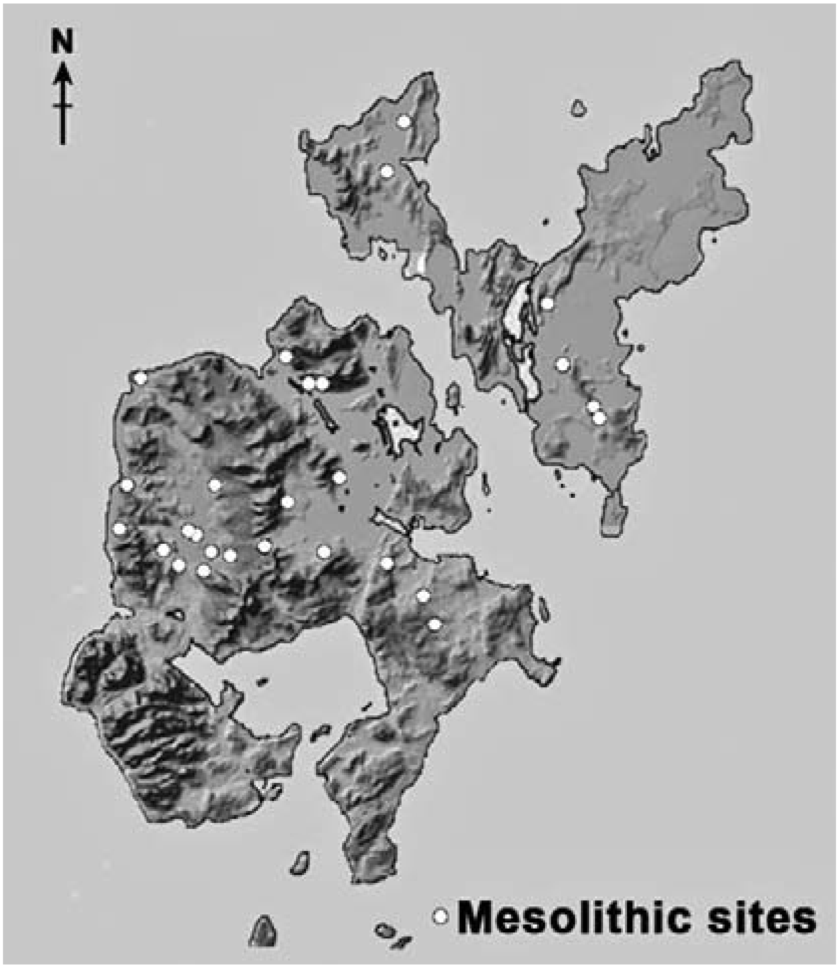


Figure 1.39 *The Orkney Islands during the Mesolithic were significantly larger. The Mesolithic sites marked were once on the coast but most were drowned as sea levels rose to their present levels around 4500 BP. (C. Wickham-Jones: Rising Tide Project)*

remains. Some of the most spectacular results have come from the area known as Doggerland between the east coast of England and Holland. Before this was finally flooded in 7500 BP, this had been dry land. Researchers at Birmingham University have mapped and produced images of the old land surface and reconstructed vegetation and fauna.

Most people think of this simply as a 'bridge' over which Mesolithic settlers walked to Britain. However, the great plain of Doggerland with its broad river valleys and low ranges of hills (today's Dogger Bank) was inhabited. Some writers have suggested that this area with slowly rising sea levels bringing marine food would have been a more attractive area for forager settlement than thickly forested parts of the mainland. Professor Gaffney, the project leader, has called it the best preserved prehistoric landscape in Europe if not the world. Around the Orkney Islands the Rising Tide Project is documenting another lost Mesolithic world.