Understanding and Using Archaeological Topographic Surveys - The "Error Conspiracy"

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Abstract

Surveys of archaeological sites form a basis for management decisions, and through the displaying of spatial relationships they are an interpretative tool. They are commonly re-used for later work, particularly if damage has occurred in the intermediate period rendering features indistinguishable on the ground. In these cases, the need for a plan to assist in both the management and interpretation of the site is fundamental. Developments in digital archiving and data management have changed the way in which archaeologists work and hold the potential for the re-use of survey data. However, the re-use of data requires an understanding of the accuracy and applicability of earlier material. This paper highlights the inherent dangers in re-using survey data using the example of an Iron Age site near Doncaster, England. The results demonstrate how errors can be perpetuated within the literature and how they continue to be used for the decision-making processes despite this.

Key words: survey, data re-use, error, GPS, aerial photography

1. Introduction

There is a long tradition within archaeology of producing plans and surveys, particularly of sites represented by earthworks. This has been common practice normally aimed at the interpretation and classification of a site by investigating spatial relationships between different archaeological features and the landscape (*cf.* Bowden 1999). It has also been seen as a basis for the management of sites once recognised. For example, legislative protection such as through English Heritage's scheduling procedure requires that an outline is drawn around the site displaying the area to be protected including a buffer zone. In order for such management to be effective, it is important to have an accurate record of the site and its location to inform the decision-making process. Finally, it is important to make surveys of sites for archival purposes to maintain a record in case of future damage or other changes to the site. If a site becomes damaged, an earlier survey may prove invaluable when directing and understanding later work. This highlights the re-usability of survey data, and the importance of maintaining such a record.

The re-usability of archaeological surveys has important implications in relation to the development of digital data management and archiving. Surveys are needed to fulfil certain requirements and are consequently conducted at particular scales. Once placed within a digital environment the potential for re-use expands due to greater ease of access. However, within such an abstract environment, the original consideration of issues such as scale and intention may be forgotten. If a survey is then re-used within an environment that has the ability to create new data from it, such as GIS (*cf.* Savage 1990), the levels of abstraction and inaccuracy are increased.

This paper presents the results from a case study on a site in South Yorkshire, UK. Here, the destruction of earthworks led to subsequent work over two decades being conducted using the earlier survey plans as their basis. The re-use of the earlier survey has proved invaluable in this case with the lack of other alternatives. However, a more recent topographic survey of the site revealed that the earlier survey was inaccurate in a number of ways, and that these inaccuracies have had an effect upon more recent archaeological work. Reflection on these issues has highlighted the dangers inherent in the re-use of previous survey data, and that the unique values of the detail shown in the earlier survey form a paradox. The need to record "metadata" when archiving surveys is demonstrated, and it is noted that previous surveys should be used with extreme caution to avoid the perpetuation of error.

2. Survey data and digital archiving

Developments within digital archiving have enabled datasets to be more freely and usefully accessible (*cf.* Richards 1997). The potential for this has been particularly marked within spatially referenced datasets and the growth of GIS-based excavations and fieldwork (Gillings and Wise 1999). Such an environment enables the results of previous research to be included within the database of ongoing work, making conclusions more easily understood through correlation, and building within a standardised framework.

Surveys are an extremely re-useable form of data. The fact that they are normally spatially referenced means that they are ideal for being included within the framework of digital archaeological datasets. Archaeological surveys of surface features such as earthworks are essentially interpretative drawings. They are representations at a given scale of an interpretation of features seen on the ground, obtained through a combination of the surveyor's knowledge and experience. Surveys therefore provide a different type of data when compared to the distribution of finds, for example, as they cannot be considered as objective. The usefulness of a survey is also determined by the intentions behind it, and this often dictates the representation scale. This determines the level of detail included and also the accuracy at which it may be accepted when re-used. With time such information as the original scale of the survey may be lost, particularly if its record exists as a secondary publication. The issue of maintaining data about data has been focused upon previously (e.g. Wise and Miller 1997, Gillings and Wise 1999), and the issue remains a fundamental theme within digital archiving.

Contemporary digital survey methods have provided a different type of product that offers a wider range of issues concerning the archiving of survey data. Increased efficiency of digital survey techniques such as differential Global Positioning Systems (GPS) have meant that the quantity of data that can be collected in a day has increased providing the opportunity to approach surveys differently (Chapman and Van de Noort in press). The collection of many survey points across an archaeological site creates the possibility of generating a highly accurate Digital Elevation Model (DEM). These can then be manipulated as an interpretative or managerial tool, but can also be incorporated and re-used within other digital datasets. It has previously been stressed that, when collecting data to create a DEM of an archaeological site, the most efficient way of generating a representation of upstanding archaeology is to survey at multiple resolutions (Fletcher and Spicer 1988). This approach meant that visible features could be surveyed at a high resolution reflecting their complexity in the same way as standard interpretative survey methods do. Other areas could be gridded to fill the gaps, providing a level of data similar to that of traditional contour models. Although this is certainly the most appropriate solution to the problem of surveying archaeology that has varying density on the ground, it raises a number of issues relating to the archiving and re-use of digital data that are different to those of previous survey methods. Firstly, it creates a problem of definition. The nature of these types of surveys is a mixture of both subjective interpretative recording and objective gridding of the surface. Secondly, the variable resolution of data points and the digital storage of the data make it very difficult to determine the scale at which the survey was conducted as with earlier approaches to survey. Essentially, at what resolution may the data be considered to still be accurate?

3. Sutton Common - a case study

3.1. Background

Sutton Common lies within an area of low-lying wetland to the northeast of Doncaster, UK (figure 1). Here, the landscape has revealed evidence of human activity from all periods since the Mesolithic, although the focus of the archaeology is on a pair of earthwork enclosures dating to the Iron Age (Whiting 1936, Parker et al. 1997, Van de Noort and Chapman 1999, 2000). These occupy early Holocene sandy "islands" on opposing sides of the relict, peat-filled palaeochannel of the Hampole Beck. The enclosures represent two phases of human activity. The first is characterised by the construction of an oak palisade around the "island" on the eastern side of the channel. The second phase is marked by the construction of earthen ramparts overlying the earlier palisade and enclosing both islands. These are formed by complex multivallation, and elaborate entrances constructed of massive oak posts. Linking the two enclosures across the relict palaeochannel was a sandy causeway defined on either side by an irregular row of stakes.

The area of Sutton Common was enclosed in the 1850s and at this time the positions of the enclosures were mapped by the Ordnance Survey, labelling them as "Crook Hills" (Ordnance Survey

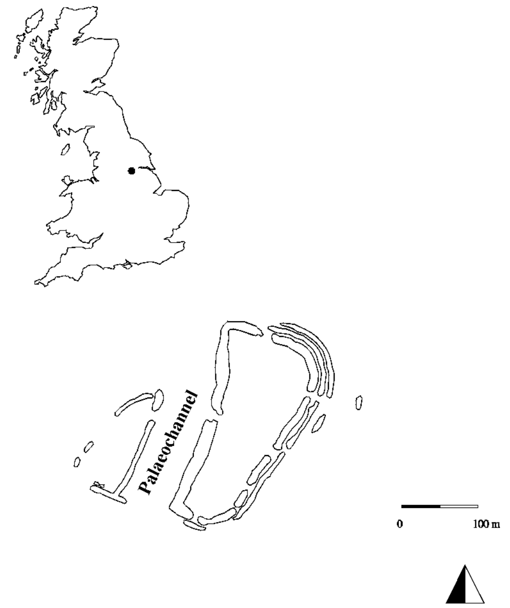

Figure 1: Location of Sutton Common. Banks of the Iron Age enclosures shown after Whiting (1936).

6" scale map (1945-54) sheets 254-301). They were again recorded by Surtees in the 1860s (Surtees 1868) and mentioned in the archaeological literature in the beginning of the 20th century (Allcroft 1908). A series of unrecorded excavations took place throughout the 1920s, but the first scientific archaeological research excavation was not until the 1930s (Whiting 1936). During the work at this time the earthworks of each of the two enclosures were surveyed by Bennett and Hill. The surveys of the two enclosures were published on separate pages within the report, and this secondary record remains their only known source. Consequently, the scale of the original survey is not known, nor are the original intentions. However, annotations accompanying each of the published surveys display text in an extremely small, often illegible handwriting. This indicates that at least some photographic reduction was involved prior to their publication.

The Sutton Common landscape was first subjected to drainage operations at the time of enclosure in the 1830s (Whiting 1936:57), although the effect of this appears to have been extremely limited. Accounts dating from shortly after this event describe the Common as still waterlogged (Surtees 1868, Allcroft 1908). Little concerning the physical landscape appears to have changed until 1979-80 when the area of the large enclosure and part of the small enclosure were bulldozed and transferred to arable farming. In 1982, this was accompanied by the installation of under-field drainage lowering the water levels on the Common by approximately 2 m, accompanied by off site water abstraction (Geomorphological Services Ltd. 1990).

The reduction in ground water levels and the potentially damaging effect of this upon the buried, wet-preserved organic resource prompted a series of excavations and investigations. These were primarily funded by English Heritage and undertaken by the South Yorkshire Archaeology Unit and Sheffield University. This work was aimed at assessing the condition of the buried archaeological and palaeoenvironmental resource and consisted of small trial trenches. For report preparation and for publication, the positions of these trenches were placed in relation to the earthworks using the 1930s surveys by Bennett and Hill as a basis (Parker Pearson and Sydes 1995, 1997). This appears to have been because there

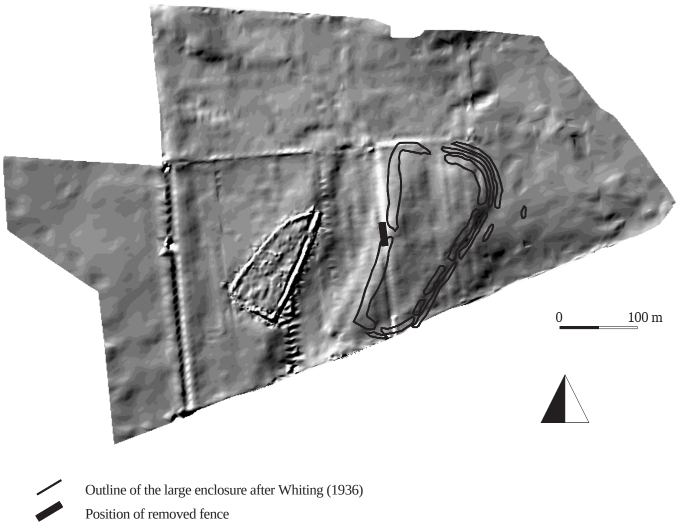

Figure 2: DEM of Sutton Common showing the positions of the georeferenced plan (after Whiting 1936) and the position of the fence used to locate it.

was no real alternative since aerial photographs taken of the Common prior to the bulldozing showed the earthworks as indistinct because of rough vegetation. The resulting maps placed the trenches in relation to the destroyed earthworks, and also brought the two surveys together to form a single plan. This formed the basis for reports on the site throughout the 1980s and 1990s.

3.2. New survey - towards a digital excavation

The ownership of Sutton Common passed to the Carstairs Countryside Trust (CCT) in 1997 for the long-term protection of the upstanding and buried archaeology, and for the wildlife upon it. The new ownership was followed by a topographic survey of the area to create a DEM of the site that could be useful for its future management. The survey was conducted using Spectra Precision's *Geotracer© system 2000 L1* differential GPS (set at an accuracy tolerance of ±0.02 m) at a variable resolution reacting to the variable preservation of earthworks as described above. The survey data were processed within ARC/INFO GIS to create an interpolated DEM at a cell-resolution of 1 m.

Two new phases of excavation of the site were undertaken in order to assess the preservation of the organic archaeological and palaeoenvironmental source material. The locations of the trenches for both were chosen on the basis of the subtleties highlighted within the DEM. The first phase of excavation opened up five small trenches across the site. The second year was more systematic, with eleven trenches positioned at regular intervals across the interior of the larger enclosure. During the second phase of excavation the bases of two posts were discovered that appeared to be parts of a fence that was positioned across the Common during the 1930s and which was included on the plan of the site made at the time (Whiting 1936:60). The alignment shown from these two posts correlated exactly with a surface feature visible on the hillshaded model generated from the DEM. Using this and the scale on the survey drawing, it was possible to georeference the earlier plan and to incorporate it into the GIS (figure 2).

The resulting correlation model revealed that the DEM reflected a high level of survival of features in the area of the larger enclosure despite bulldozing and two decades of arable cultivation.

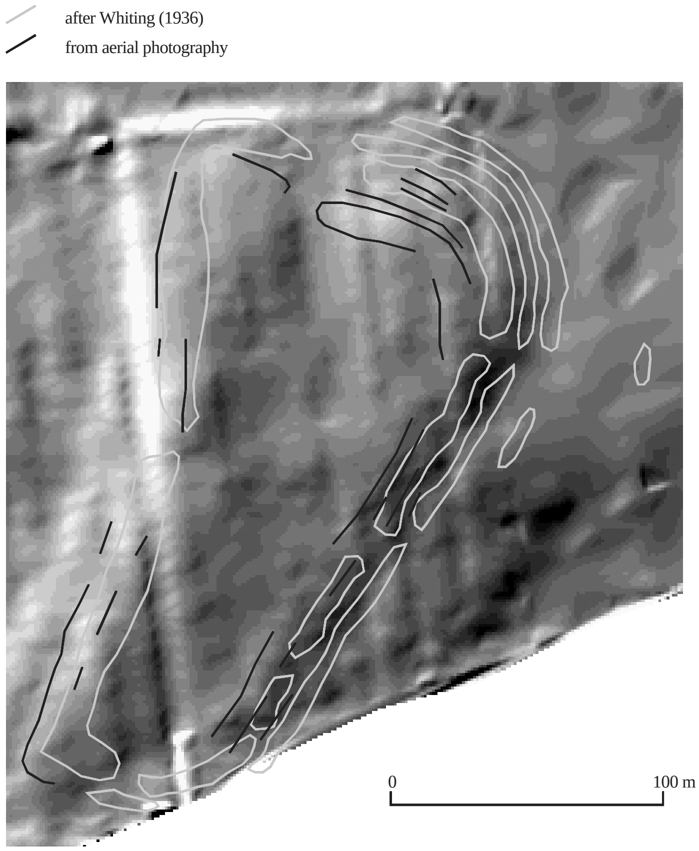

Figure 3: Differences between the positions and dimensions of the larger enclosure.

However, comparison with aerial photographs taken of the site before it was bulldozed and ploughed revealed that the position of the integrated outline was incorrect. The georeferenced outline of the larger enclosure existed further north than it appeared on the aerial photographs, extending onto the modern track. The photographs showed it stopping short of its southern side.

In order to understand the level and areas of error within the incorporated 1930s survey it was important to obtain a more accurate outline of the buried archaeology from the available sources. Aerial photographs taken during the excavation were consulted for their limited cropmark information that may indicate the outlines of the banks and ditches of the larger enclosure. Through a process of colour separation (by J.G.C. Tovey) it was possible to strengthen vegetation differences highlighting the positions of the buried archaeological features. The photographs were rectified and georeferenced using the outlines of the eleven excavation trenches that were visible and that had been surveyed on the ground using the GPS with positions located on the DEM. The outlines of the visible archaeological feature revealed on the colour-separated aerial photographs were digitised and incorporated into the GIS model (figure 3).

3.3. Identification and classification of error

The identification of error within the plans from the 1930s surveys may be classified into three main levels: primary, secondary and tertiary. Primary error relates to errors inherent within the survey itself. A number of errors could be seen in relation to the basic identification of archaeological features. For example, on the western side of the small enclosure, the bank was depicted on the earlier survey as a series of interrupted mounds with breaks

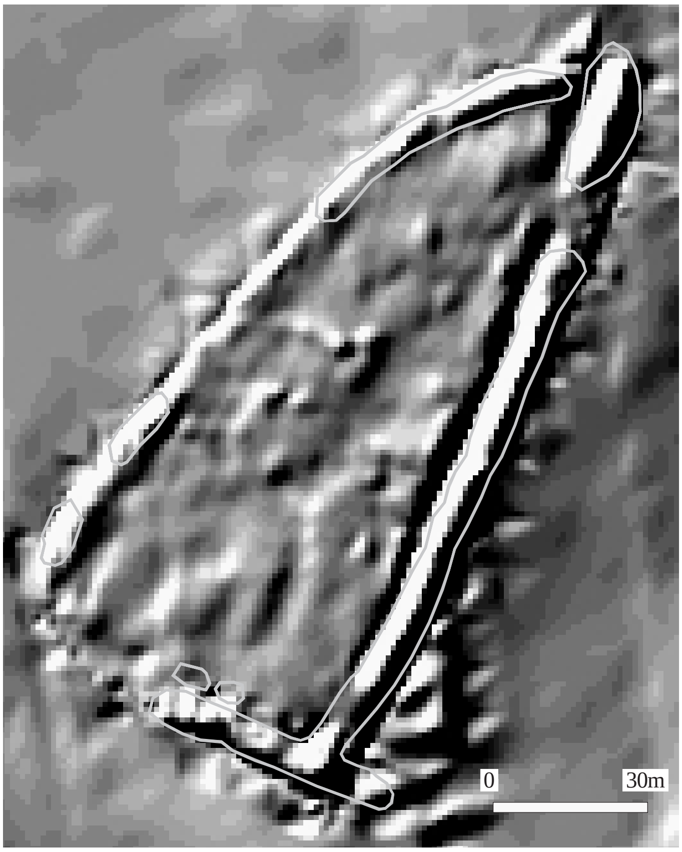

Figure 4: DEM of the smaller enclosure compared with the outline of the banks from the previous survey (after Whiting 1936).

between them (figure 4). The GPS survey, on the other hand, showed a surface that consisted of a near-complete linear bank. It seems that the rough vegetation at the time of survey may have hindered the recognition of the banks on the ground, but the systematic GPS survey was able to pick up these features. A similar result was found on the eastern side of the smaller enclosure where the entrance was formed by a break in the two banks. On the GPS survey this break was less distinct and more spread, indicating a more complex process. This was noted within the excavation of this area that showed evidence of major slumping of material in antiquity (Van de Noort and Chapman 1999).

Secondary error is generated when surveys are depicted according to convention or prepared for publication. At Sutton Common the original scales of the surveys by Bennett and Hill are now known. It appears that they were not redrawn prior to publication as the survey grid lines are visible. However, the size of the writing indicates that they have been considerably reduced, indicating a possible loss of detail and some distortion through the photographic process. Without records of this it is not possible to understand the reliability of the plan in the publication and therefore a second level of potential error is added to the process.

Tertiary error may be generated when a previous survey is re-used and depicted in another way. This level of error relates to the processes that are applied to the plan by the new user, and can include basics such as accuracy of digitisation, chosen points for digitising, data format conversions and its role within further calculations by the GIS. The latter point is particularly important since the reproduction of multiple layers of data and their use for future decision-making processes can abstract it (cf. Savage 1990). Levels of abstraction increase the chances of separating a surface from metadata, meaning that levels of potential error may be forgotten.

3.4. Quantification of error - the larger enclosure

In order to understand the apparent error contained within the 1930s survey compared with the aerial photographic rectification, a quantifiable basis was required. The fragmentary nature of the outlines from the aerial photography meant that measurements were taken to areas that could be identified on these and the other surveys. This was done by constructing a base line along the western edge of the enclosures and measuring off at 90 degrees from percentile positions. These provided actual lengths and width to height ratio lengths of the enclosure.

3.4.1. Size and scale

The length of the two enclosures differed by c. 3%, with the width nearly 13% wider at the northern end and 6.5% towards the southern end for the 1930s survey compared to the later survey. This showed that the scaling of the earlier survey had made the enclosure larger than it was.

3.4.2. Rotation

The earlier survey is rotated by nearly 3° anti-clockwise from that revealed from the aerial photography. The main reason for this appears to have been due to a bend in the western bank of the enclosure north of the western entrance. The earlier survey did not recognise this, perhaps due to the obstructions caused by the fence that separated these two parts of the site at the time. As a result this change in alignment is not reflected in the earlier survey. Rotation has been seen as a source of error in some of the publications that have re-used the earlier survey (cf. Parker Pearson and Sydes 1997:222).

3.4.3. Integrity

In addition to the earlier survey demonstrating inaccurate scaling and some rotation, the internal integrity of the survey appears to have been incorrect. If integrity was apparent then you would expect a similar size increase for all measurements relative to the aerial photographic work. However, while the length was greater by approximately 3%, the width at the northern end was 13% greater. Further, the southern end was only about 6.5% greater. Two conclusions may be drawn from this evidence. Firstly, the width increase was greater than the length increase, suggesting a lateral stretch. Secondly, this lateral stretch was not consistent, with greater expansion displayed in its northern part.

4. Discussion

The discrepancies between the positions of the outlines of the larger enclosure displayed on the 1930s survey and the aerial photographs may have occurred or been influenced by a number of factors. These include surveying errors, but it has also been suggested that lateral movement of sediments is possible through natural processes, particularly on wetland sites (S. Stead pers. comm.). Since Sutton Common is a wetland it may be expected that the natural landscape is dynamic, and that the drainage of the site during the past two decades will have altered the burial conditions. This has been noted by the differential shrinkage of the various sediments across the site, particularly between the biogenic and minerogenic material (Chapman and Van de Noort in press). Although it seems likely that such changes to the natural environment will have altered the surface topography, this will have been to a minor extent. The majority of the site is represented by the reworked minerogenic glacial lake sediments that are less likely to shift compared with the areas of organic material. Also, the basic evidence for the inaccuracy is the false extension of the larger enclosure onto the track to the north. Such excessive error cannot be understood solely through natural processes, although it will have been influential at a lower scale.

Discounting natural processes as having a minor effect on the surface topography of the Common, the reason for the discrepancy in the location of the larger enclosure lies within the accuracy of the original survey. Without knowledge of the intentions and methods of survey it is not possible to understand the relevance of the depiction. Other factors influencing its accuracy have also been mentioned, including potential problems during reproduction for publication, and its conversion into a digital format.

5. Conclusions

The importance of archaeological survey is well established, particularly its potential for re-use, and the integrated advantages that this may have within digital databases. However, without consideration of the many levels of error that may be inherent within the survey, such re-use holds the potential for generating inaccuracies that may not be recognised. This paper has demonstrated how such errors may "conspire" to create results that are far from accurate and that produce an incorrect, or at least misleading, picture of the archaeology on site.

The implications of this for archaeology are far reaching. In terms of interpretation, errors will create different spatial relationships between different monuments, and between monuments and the landscape. Further, such error cannot be understood in terms of fuzzy tolerances due to its non-linear nature. In terms of resource management, the implications are also very high. Sutton Common is protected under English Heritage scheduling policy. Scheduling requires a boundary to be drawn on a map to outline the area of protection. Error in the survey may mean that the wrong area is protected. It is important therefore to critically assess data prior to its use for archaeological requirements.

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