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The contribution of GIS to the study of landscape evolution in the Yorkshire Dales, UK

1 Introduction

This paper sets out the background to the application of GIS to a long-term research project on archaeological landscapes in the Yorkshire Dales. A pilot project has identified roles for both GIS and CAD software in providing a digital map-based environment for storing and analysing data from fieldwork. The facilities offered by the software will support new approaches to investigating the landscape, but the increased sophistication of GIS software in particular places greater demands on the quality of the data being analysed. The pilot project has helped to clarify long-term goals, introduce new goals and develop strategies for data collection.

The study area is in the Yorkshire Dales, in the uplands of northern England between the Stainmore Gap in the north and the Aire Gap in the south. The highest point is Whernside at 736 m OD, and the area includes the highest hillfort in England on the summit of Ingleborough (723 m). Within this study area, the pilot project has concentrated on an area 10 × 12 km between the northern end of Wharfedale and Wensleydale, roughly between the villages of Buckden and Bainbridge. This area reflects the general topography of the Yorkshire Dales — long, narrow glacial valleys dissecting areas of upland. The nature of the Dales landscape suggests that GIS software will be particularly useful: extremes of topography are concentrated within a relatively small area, and provide an important backdrop to the development of settlement patterns from prehistoric times to the present day. Environmental data relating to climate, vegetation and geomorphology constitute a suite of variables that is now a traditional element of locational analysis in archaeology. GIS software offers the ability not only to store the large amounts of data involved, but also to develop new ways of visualising the complex interaction between them. Given the marginal nature of the study area in terms of subsistence exploitation, small changes in environmental variables can be expected to have a significant impact. There is no arable production in the study area at present, for example, but extensive field systems show that cultivation penetrated high into the Dales in the past. The pilot project focused attention on the nature of the archaeological evidence in the study area, and the role of GIS in supporting future developments. These two issues are considered below.

2 The nature of the archaeological evidence

Twenty years ago Challis and Harding wrote in their review of the north of England in later prehistory: ‘The present state of archaeology in the limestone areas is desperate. There is no individual site report yet available despite numerous small excavations. Publications are of a generalised and imaginative nature.’ (Challis/Harding 1975: 184). The traditional model of later prehistoric settlement in the region was based on the belief that ‘..the capacity of the Pennine dales to support population was severely limited. Semi-nomadic pastoralism was the only practicable way of life.’ (*ibid.:* 185). This view has a long history, arising from the work of Wheeler at Stanwick, and Piggott’s description of ‘Celtic cowboys and shepherds, footloose and unpredictable, moving their animals over rough pasture and moorland...’ (Piggott 1958: 25).

Recent work has begun to challenge this picture of northern England towards the end of the prehistoric period. Evidence from Stanwick shows a greater emphasis on mixed agriculture (Haselgrove *et al.* 1990), but this important site lies in a relatively rich lowland area on the fringes of the Dales. Within the upland area the Swaledale Ancient Land Boundaries Project has identified extensive field systems and a permanent settlement pattern originating in at least the middle Iron Age (Fleming/Laurie 1990, 1992). Other work in the Dales area is adding to the evidence for a widespread settled landscape first identified by Arthur Raistrick (Raistrick 1939).

One of the major problems currently facing any investigation of the archaeology of this area is the lack of chronological data. The identification of sites as ‘Iron Age/Romano-British’ is frequently based on comparison with sites that were explored in the last century without reference to stratification, or excavations earlier this century before the availability of radiocarbon dating. Fleming’s excavation of a house platform at Healaugh in Swaledale has indicated the unexpected chronological depth that may be awaiting a closer examination of settlements and field systems (Fleming/Laurie 1990). The earthwork evidence associated with past settlement in the Yorkshire Dales is impressive in its extent and complexity, but it represents a palimpsest of landscape evolution from at least the Bronze Age to modern times. Patterns of exploitation have changed, for example, from Mesolithic hunting to later prehistoric farming, and large-scale sheep farming on monastic holdings in the Medieval period. Alongside this must be set the exploitation of stone and mineral resources from prehistoric to industrial times. All of this evidence can potentially be located in space and time, but the only incontrovertible data currently available describes spatial location. The statistical analysis of spatial patterning within the evidence is still a goal for the future, and data collection towards this goal must encompass more than just the morphological classification of archaeological remains (Fleming 1976). GIS software can play an important part in the management of the multidisciplinary data that are essential for future investigations, and the rest of this paper considers its role in relation to the particular problems that arise in the Yorkshire Dales.

3 The role of GIS

The requirements of cultural resource management and academic research provide the rationale for the use of different levels of functionality within a GIS. The collection of spatially-referenced data on antiquities continues the tradition of Sites and Monuments recording that is now an integral part of the planning process for new building development. Within the Yorkshire Dales study area there are several organisations whose interests impinge on the management of archaeological remains, mainly through control of the planning process and the provision of subsidies to support traditional farming practices. The full functionality of a GIS is perhaps not essential for these management purposes, since CAD software is capable of providing adequate map-based output of known archaeological evidence matching specified criteria. For research purposes, there is an additional requirement to manipulate data from a range of different sources in order to analyse the archaeological evidence, and GIS software provides useful tools for this task.

The pilot project has identified important considerations for defining the structure of a spatially-referenced data set, one of the most important being the flexibility to accommodate increasingly detailed data from a variety of sources. Existing archives use six or eight figure National Grid References to record data from maps and aerial photographs commonly at 1: 10 000 scale, and some of the conventions used in these archives may not transfer easily into a GIS environment. Multiple entries with identical locations are allowed, for example, as well as the use of a single grid reference to represent an area of poorly defined archaeological evidence. Examination on the ground can add considerable detail to the evidence visible from aerial photographs, and excavation and sampling will contribute still further to what is visible on the surface. The minimum resolution of the software is a single pixel, and the scale that this represents on the ground obviously needs to reflect the level of detail expected in the data.

There is a practical problem in parts of the study area in the reverse process of working from data derived from maps and photographs to specific locations in the field. The National Grid is an abstract system that is not visible on the ground, and in remote moorland with few obvious natural features it can be difficult to identify eight-figure grid reference locations precisely. A hand-held Global Positioning System has been used in the pilot project to overcome this problem, but in some cases the accuracy and precision of such a system may be far greater than that used in the original record. Many entries in the Sites and Monuments record are based on field observations that were recorded as annotations on 1: 10 560 maps, and where the evidence is very slight or of doubtful identity it can be extremely difficult to find it on the ground. This process of field checking is an important continuing process. It would not be wise to build sophisticated GIS models using data that had not been subjected to such an assessment, and so a record of the checking process itself becomes part of the data set.

An improvement in the quality of surveyed field data will enable questions to be raised about the definition of individual ‘sites’ and their inter-relationships within archaeological ‘landscapes’. At a functional level of interpretation it is currently impossible to be certain where a ‘site’ begins and where it ends, since spatial association is no proof of contemporaneity. Moreover, small moorland settlements may have been part of a transhumance system that integrated widely separated yet contemporary elements of the settlement pattern. Data structures and manipulative techniques in a GIS will need to be sufficiently flexible to accommodate both present uncertainties and future developments, allowing links between landscape elements to be easily established and updated.

Exploitation models of Dales landscapes will increase in complexity with improvements in chronological data, but these data will themselves carry varying degrees of uncertainty depending on whether they were obtained by, for example, radiocarbon dating or typological comparison. The relative dating of some landscape elements may be based on spatial relationships such as overlapping distributions or differing orientations, as proposed for the field systems at Grasssington (Raistrick 1938). These attributes need to be included in usable form in a GIS environment, so that landscape evolution can be investigated as a dynamic process. The development of temporal functionality within GIS is an area of current interest (Castleford 1992), and the implications for manipulating archaeological landscape data are of obvious importance.

Environmental evidence will play a significant role in understanding the settlement patterns of the Dales. One of the strengths of GIS is the ability to manipulate three-dimensional data, allowing the investigation of the relationship between settlement, environment and topography. Given the marginal nature of the area, settlement models may reflect different agricultural strategies in different climatic conditions. Extremes of altitude are likely to influence exploitation strategies in addition to the basic background of geology and soils. It is common now to see archaeological distributions plotted against these environmental factors by GIS software, but new combinations of variables can be used to model factors, such as exposure, that are likely to have exerted a significant influence on settlement location. There is as yet no clear evidence to link high-altitude sites in the Dales to an expansion of settlement during the climatic optimum of the Bronze Age, which might be expected by analogy with other upland locations in England. Another key area for research is the spread of Anglian and Norse settlement, and the extent to which it filled in, supplanted or extended existing Romano-British settlement patterns, and this too may be related to the attractiveness of different locations for settlement. GIS software can be used to model the distribution of 'favourable' settlement areas using varying criteria, comparing different models with the observed distribution of relevant sites. This is currently limited to a static, synchronous approach, and the analysis of evolutionary processes remains a challenge for the future that may exceed the capacity of a GIS.

The definition of different boundaries to study areas can have a significant effect on the results of spatial studies (Martlew 1981: 37). Our modern perception of the Dales landscape tends to influence approaches to investigating its archaeology. In the uplands between the Dales, the growth of peat has undoubtedly masked some of the archaeological evidence, and further fieldwork is necessary to confirm that blank areas on the distribution maps are indeed archaeologically sterile in terms of settlement evidence. Lithic scatters are often encountered in this zone, but their study is seriously biased by the long tradition of flint collecting that exists in this area. It has been estimated that four fifths of the flint implements recovered have not been reported or provenanced (Roger Jacobi, quoted in Spikins 1993: 9) Particular concentrations of detailed evidence may be nothing more than a reflection of modern archaeological activity, and this needs to qualify any GIS models of past exploitation.

Topography provides a neat division for study areas based on individual dales, with a large proportion of the earthwork evidence surviving on the lower dale sides. Modern lines of communication follow these lower slopes, but it is clear that some Roman routes at least followed the high ground. Focusing on the dense and accessible distributions of sites on the lower ground may possibly introduce a chronological as well as a spatial bias, but this hypothesis remains to be tested. With settlement concentrations on the break of slope between the steep dale sides and the flat, marshy dale floors, the visibility of archaeological evidence may be affected by alluviation, as well as by subsequent use of the same restricted zone. This must also qualify work with GIS models, but as yet there is little in the way of hard data on which to assess archaeological visibility.

As well as influencing the results of spatial analyses, boundaries are an important aspect of landscape evolution. Documentary evidence provides hints of land use back to early Medieval times within administrative units that have changed over time, and the record includes detailed lists of topographical features and artificial markers along disputed boundaries. Identifying these boundaries in the field, and investigating the surviving evidence for land use associated with different areas, can help to identify different chronological phases in the evolution of the landscape. GIS software is capable of manipulating different subsets of the data, once the boundaries have been located by a combination of documentary research and fieldwork.

4 Conclusion

Traditional quantitative methods of spatial analysis are not appropriate at the current stage of investigation into the evolution of the Yorkshire Dales landscape. The quality of the archaeological evidence is not yet good enough, both in terms of chronology and the detailed morphology of sites. A small-scale pilot study has shown that GIS software offers considerable potential through visualisation and modelling, rather than statistical techniques. The topographical extremes in the study area, and its marginal character for agriculture, are likely to mean that environmental factors will have played a significant role in landscape evolution. Data representing the physical and environmental background can be manipulated in a GIS to produce new, composite variables for inclusion in hypothetical models, and subsets of the data can be selected to take account of different subdivisions of the landscape in the past.

The clearest result of the pilot study is that significant improvements must be made not only in the quality of archaeological data, but also in the quantity of supporting data that must be included in an investigation of landscape evolution. The value of GIS software lies in its capacity to support new ways of modelling and analysing spatial data, beyond simply acting as a sophisticated graphical output system for standard database queries. Continuing fieldwork will improve the data set, and while GIS software has much to offer at this early stage of the project, it too must continue to develop if it is to support more complex models of landscape evolution in the future.

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