Model Landscapes: on the use of GIS in archaeology.

The last ten years or so has seen ever more powerful computers becoming available at relatively low cost. Advances in computational speed and data storage, coupled with a growing awareness and access, have resulted in the almost ubiquitous use of Geographic Information Systems (GIS) for the manipulation and presentation of spatial data in archaeology. Vast quantities of data can be quickly processed, modelled, analysed and presented by computer programs and although they may not be designed for archaeology, being aimed at planning, logistics, oil exploration, and other 'high value' commercial applications, can nevertheless be used to good effect. A recent development in the UK was the presentation of Lidar data within GIS, the primary purpose of which was to enable flood water studies, but is now revealing many hitherto unknown archaeological features. Like so much in archaeology we borrow and adapt innovation designed for others (Fig.1).

Much of the data we seek and manipulate in archaeology has some spatial component that we use to build our interpretations. It's a technique that can be tracked back at least as far as, for example, the work of Pitt-Rivers who presented clear plans and sections locating, in 3D, all the artefacts recovered from his work on Bokerly Dyke (Wheatley & Gillings, 2002). The modern trend towards cartographic presentation can probably be traced back to the 'New Archaeology' of the 1970s and today we see the use of GIS in presenting maps, the distribution of artefacts on a single site, the distribution of trenches over a wider area of interest, monuments across the country and many other applications.

Indeed the use of GIS in presenting archaeological data is so commonplace that we accept it without even recognising the GIS process that goes in to building the model. And that is how it should be .

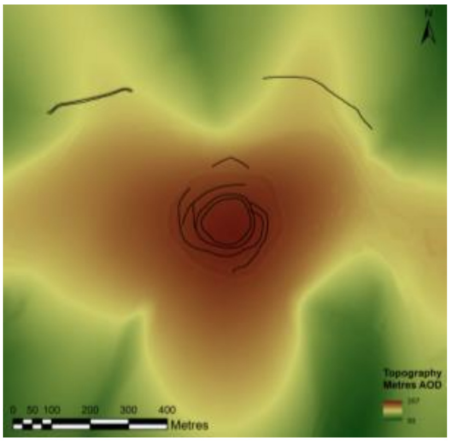

Figure 1 – The Trundle (Sussex)
Lidar data, superimposed on a Digital Terrain Model (DTM) where the higher ground is shown brown and low ground green. This coarse Lidar provides a resolution of 100cm over the Chalk Downs but still clearly shows the contours of the pentagonal Iron Age hillfort. The remains of the early Neolithic causewayed enclosures within the hillfort and the external cross-dykes are less obvious and here are sketched in, based on a combination of field survey and geophysics. The GIS provides the ability to quantitatively relate the causewayed enclosure to the immediate, surrounding and national topography.
Spatial data: Edina Digimap, Crown Copyright/database right 2010. An Ordnance Survey/Edina supplied Service. Lidar data:

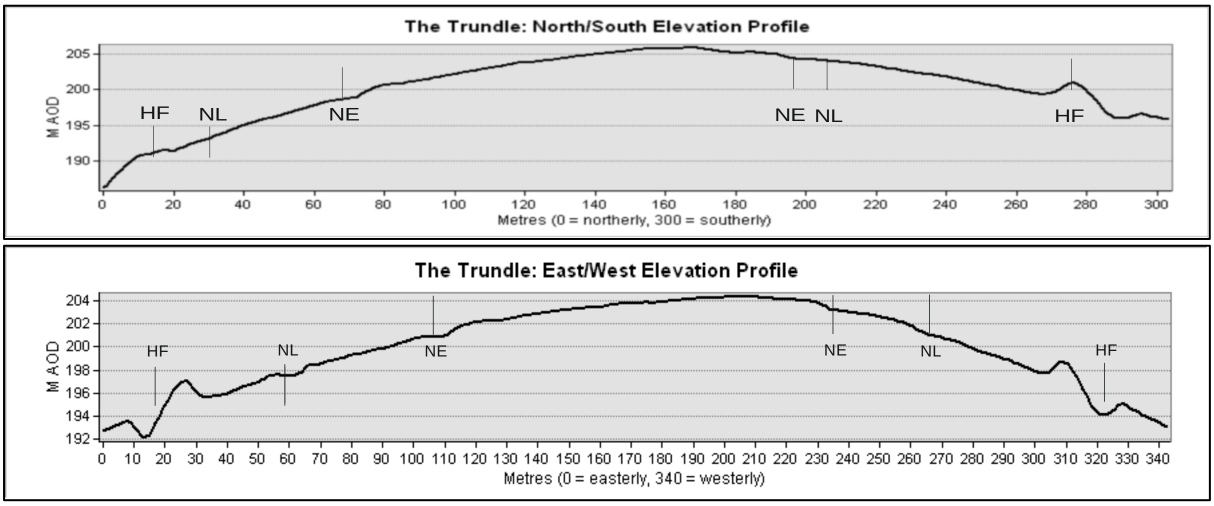

Figure 2: Elevation profiles for The Trundle.

HF, NL, NE: Earthworks associated with the Iron Age hillfort and with the Neolithic linear features and enclosure, respectively. Here the GIS is used to slice through the hillside, itself derived from the Lidar data, to provide a profile in 2 directions. The profile is derived from the same dataset as that in Figure 1 but the GIS has allowed the scale to be changed and now shows how the Neolithic components are reflected in the data. Whilst, in east-west direction, the enclosure is broadly positioned at equal elevations across the brow of the hill, the north to south orientation shows a bias toward the northern aspect.
Spatial data: 1m resolution Lidar data, Geomatics – The Environment Agency

GIS systems range from the free 'open-source' applications like GRASS GIS (http://grass.osgeo.org/) to commercial offerings like ARC GIS (http://www.esriuk.com/) which can cost many thousands of pounds (though are offered for personal non-commercial use at less than £100 per year). All use the same underlying concepts of presenting vector data (points, lines and polygons) and raster data (pictures, built up as 'cell values') and providing mechanisms for storing, manipulating, analysing and modelling these so-called 'primitives' and presenting the results, projected to a scale and within a coordinate system, that corresponds to the needs of the user. The difference between the various systems is reflected largely in the user interface, and the power and range of the analytical tools provided. The design of some GIS leans towards either vector or raster data.

This short contribution is aimed at introducing just two analytical techniques used in the archaeological study of landscapes and draws some examples from the author's current work in researching the landscape context of early Neolithic causewayed enclosures. We shall look first at 'visibility analysis', for example what you can 'see' from a given monument, or where you can see it from (no – it's not always the same) and then 'least cost modelling', that is what is the easiest way of getting from site 'a' to site 'b', or what resources could someone living at site 'a' reasonably exploit. The results should be considered 'work in progress'!

First we should give some caveats.

Despite the ubiquitous use of GIS in many areas of archaeology the use of the technique in landscape analysis has received criticism in the literature, particularly for its emotional detachment from the landscape it claims to analyse and for its apparent quantitative and mechanistic approach. For example:

> *GIS provides a dumb, indeed surreal, view of landscape in which everything is equally visible and therefore equally important – which is clearly never the case - and, of course, it can only cope with the visual rather than with other forms of sensory experience. Like any other mathematical technique, it is terribly impoverished and inevitably makes inhuman assumptions in the form of the modelling that is involved. In short it is incapable of providing an embodied encounter with a landscape, or a monument, a feeling for the place in which the place itself exerts its agency, exerts its own powers in relation to human perpetual experience* (Tilley, 2010, 477).

And Cummings was equally critical, if more concise: "*Quite simply GIS cannot replicate the experience of being in the landscape so was not used here*" (Cummings, 2009, 127). Others also recognise that vision is anyway, only one of a number of human senses and have argued that visibility is over-emphasised in landscape studies. For example Ingold maintains that a "multi-sensory and kinesthetic dimension" must also both be considered as part of any spatial experience (2000, 158-197) where audio, 'feel' and memory also play key roles.

We may think that with such criticism we are wasting our time with GIS: nevertheless even visibility remains an important facet of most scholarly works of monument and landscape analysis and the same protagonists concern themselves with intervisibility between monuments (e.g. Tilley, 1994, 133-4, 156-159), with astronomical associations (e.g. Bradley, 1993, 52&100-104), whilst others relate a particular monument or monument group to distance landscape topographical features (e.g. Cummings et al., 2005, 47). Llobera (2007, 66) suggests an inability amongst archaeologists to embrace computer-based modelling is partly responsible for this stance and like David Wheatley and Mark Gillings (2001, 28-29; 2002) and LK McNamara-Kearin (2013) a decade later, argues that, carefully deployed, GIS can play an important part in such analysis: in particular in extending beyond 'just' the visible and including the quantified topography, geology, and hydrology.

Visibility analysis (viewsheds)

The underlying framework of these studies is the digital elevation model (DEM) which can be mathematically interpolated from contour maps available from, for example, the Ordnance Survey (OS). A model is built up within the GIS where each cell represents a spot height on the ground onto which we place our archaeology. From this we simply look out onto the landscape from our monument (or from the landscape to our monument) and the GIS predicts what is and what isn't visible from a given location.

There are many real problems with this approach which have drawn valid criticism. Interpolating the terrain from the contours is itself a process subject to error. The underlying map data have errors and the mathematical modelling compounds these and introduces more. As such, GIS modelling is subject to all the attendant frailties we associate with interpretation: weaknesses which are further compounded by measurement error, model errors, and assumptions made within the input dataset (e.g. Gillings & Wheatley, 2001; 2002, 83-86; McGwire et al., 1996). Not the least of these is the degree to which the modern topography, on which our spatial data is based, is representative of the early landscape. Where we can estimate the difference (e.g. Mercer & Healy, 2008, 7-8; Robinson et al., 2013), we can account for it in the model; however there will be examples where this cannot be estimated with a sufficient degree of confidence.

Other errors relate to the characteristics of the landscape under study. For example an early Neolithic landscape analysis requires a detailed understanding of a landscape, which by definition, is undergoing transition. The improved temporal resolution offered by the statistical interpretation of radiocarbon data (e.g. Whittle et al., 2011) emphasises the rapidity of landscape transition in the period of enclosure construction: this changing landscape is rarely reproducible by the archaeo-environmental record in the landscape 'between the monuments'. Whilst detailed environmental investigation has been carried out at a number of sites, and an environmental record for this period may be provided as a spin-off from other site investigations, the record is patchy and less clear regarding, for example, changes to vegetation, riverine morphology and marine encroachment in the large areas between sites that have not benefitted from such detailed archaeological investigation. The literature has many examples where vegetation, invisible to the GIS, plays a key role in interpreting the monuments environs (e.g. Whittle et al., 1999, 382). Despite this, I would argue, that GIS-based analysis can play an important role in trying to understand the sense of place embodied in the positioning of some monuments within their local environs and whilst it may be unlikely that visibility is the only determinant in positioning, for example, a causewayed enclosure on the summit of a chalk hill, it was surely one factor in the decision making process.

The equal importance argument presented earlier by Tilley can be accounted for, to a small extent, by modifying the visibility model through the introduction of a distance decay function. This shifts the analysis from presenting viewsheds as simple, binary, in-view / out-of-sight models, to one where distance can be represented: where more distant landscape features are reflected differently to near view ones (Ogburn, 2006). A further refinement can be to reflect contrast, big objects can be treated differently to small ones, or those with high contrast (chalk capped barrows for example) emphasised over the background landscape. These can be accounted for in the mathematical model and reflected differently in the resulting presentation and interpretation (Fisher, 1994). These more complex 'fuzzy viewsheds' overcome some of the shortcomings of the simple binary model. Intervisibility analysis may be considered on a simple individual pair (single observer and single target), or as an intervisibility network (multiple observer, multiple target) basis. In constructing a visibility model an important consideration is the constraint imposed by distance and hence the dimension of the zone or buffer placed around the observer point. Without such a constraint the model may suggest intervisibilities that are simply not practical.

Case study 1 – Visibility Analysis of Causewayed Enclosures on the Sussex Downs – *to follow next month, together with the bibliography.*

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