Model Landscapes: on the use of GIS in archaeology – Part Two

Case study 1 – Visibility Analysis of Causewayed Enclosures on the Sussex Downs

Figure 3 gives an example of an intervisibility network. The increased geographical range has generated a need for a different dataset for the digital terrain model (DTM) which now has a limit of accuracy corresponding to 10m per cell. That is, if we consider the DTM to be made up of grids of cells, where each cell reflects 10m on the ground, then each cell within the grid has only one value that corresponds to its elevation in the real world. Here the lines between the monuments are indicating the predicted intervisibilities between them, whilst the colour of the lines indicates areas within the landscape that are visible from the 'observer' enclosure at one end of the line. The model predicts that all enclosures intervisible with The Trundle, whilst, for example, the enclosure at Court Hill is only intervisible with The Trundle.

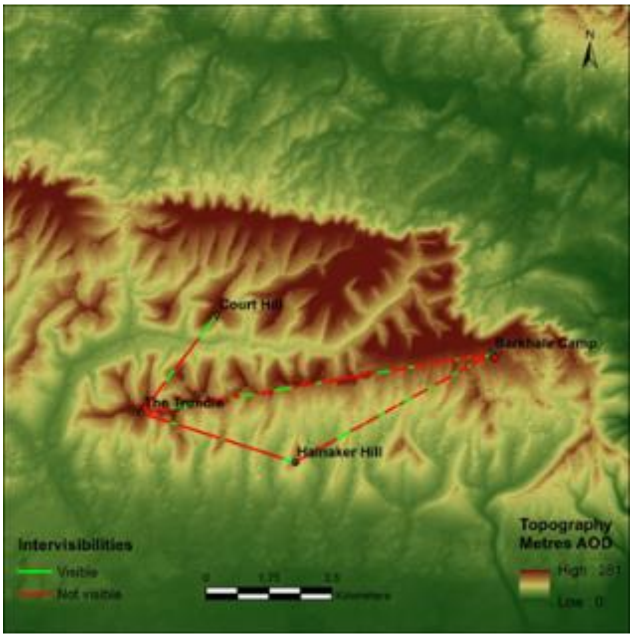

Figure 3.
Visibility network for the cluster of four causewayed enclosures in West Sussex
Spatial data: Edina Digimap, Crown Copyright/database right 2010. An Ordnance Survey/Edina supplied Service.

Figure 4 below is an example of two 'fuzzy viewsheds' looking from the highest point within the Coomb Hill and Halnaker Hill causewayed enclosures. The visibility is largely constrained by the immediate topography. In these models, more distance views are shown diffuse (orangey yellow) whilst the more immediate views are more emphatic. Combe Hill is unusual in the Sussex group in having its primary direction of view away from the coast.

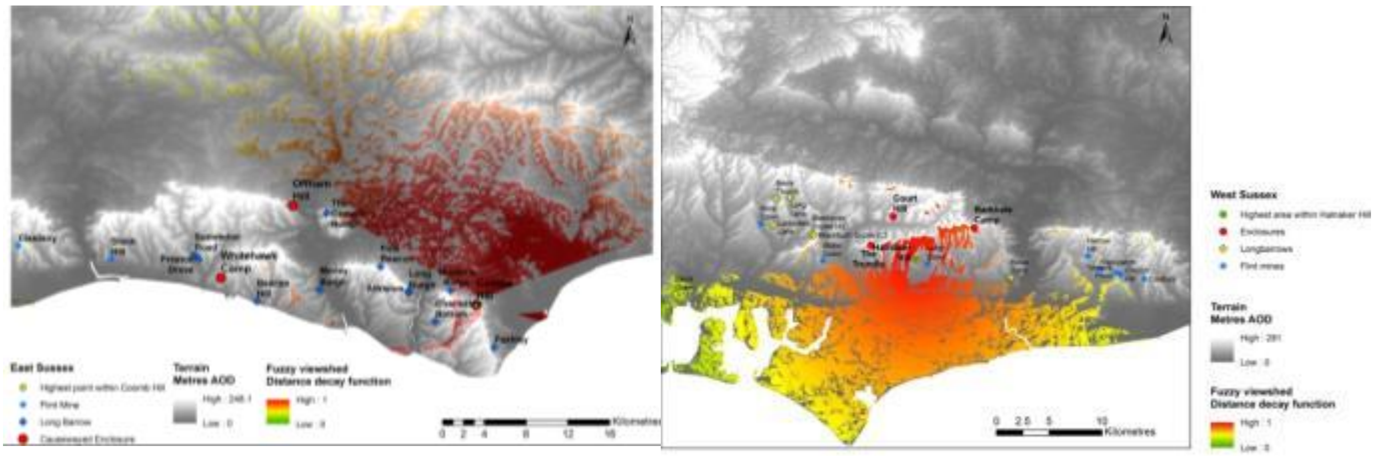

Figure 4. Fuzzy viewshed for the causewayed enclosures at Combe Hill and Halnaker Hill (Sussex)
Spatial data: Edina Digimap, Crown Copyright/database right 2010. An Ordnance Survey/Edina supplied Service.

Figure 5 takes all four causewayed enclosures of the westerly group, The Trundle, Halnaker Hill, Court Hill and Barkhale Camp. The model, which is a summation of four binary viewsheds, demonstrates how we can combine individual models to establish an ‘index of visibility’ for the landscape. The resultant analysis shows those areas of landscape that may be visible from none, one, two, three, or all four, of the enclosures. Of notable interest is the relationship with the broadly contemporary long barrows and flint mines, most of which appear to be outside of the visual range of the enclosures. Also noteworthy perhaps is the strong southerly or coastal bias associated with the primary views.

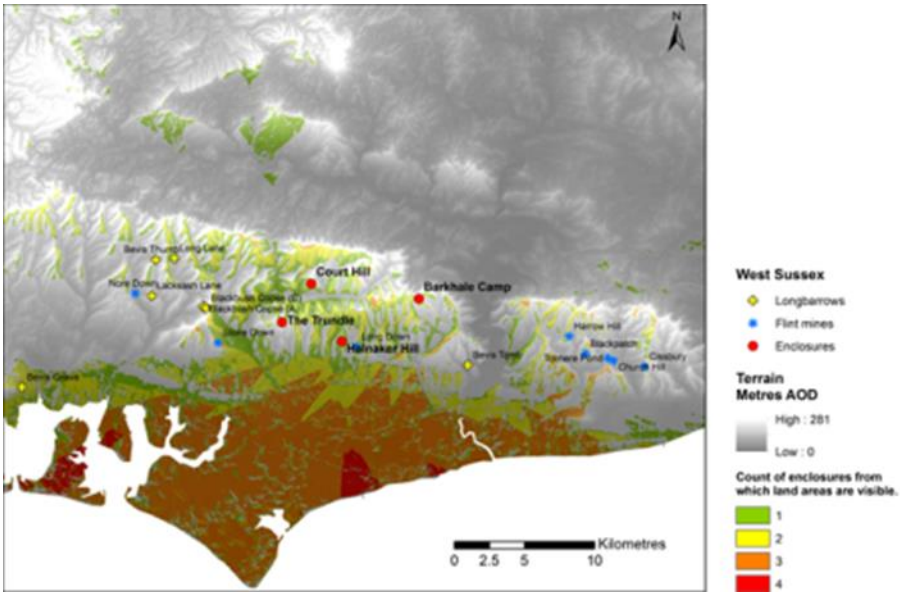

Figure 5.
Fuzzy viewshed for the causewayed enclosures at Combe Hill and Halnaker Hill (Sussex)
Spatial data: Edina Digimap, Crown Copyright/database right 2010. An Ordnance Survey/Edina supplied Service.

Cost modelling.

Here the objective may be to postulate route ways or communication paths between monuments (Bell & Lock, 2000; Lock, 2003) or to estimate the likely areas associated with, in this case, causewayed enclosures. Again the DEM provides the foundation and the mechanics of this technique involve building up a ‘cost surface’ within the GIS, where the movement between individual cells can be expressed in terms of the human effort required to move between them. The cost surface takes two forms: an isotropic cost surface, useful where the direction of movement does not matter in the calculation and the more normal case where it does, for example in travelling up a slope, down one, or moving along the level. The cost surface hence needs to include aspects of topography such as slope, direction of slope, direction of travel, and elevation, as well as hydrology etc. Account is then taken of these factors according to the degree of effort that may be associated with each variable and mathematical equation that define the overall expenditure of effort. It is important to note that ‘cost’ or friction surface is an abstract concept rather than a real one and it is most usual to convert this into time taken or energy expenditure.

Again we must make some interpretive assumptions. For example, modern hydrological conditions may not correspond to prehistoric ones. Rivers have been diverted since at least the Roman period, were less canalised than today, and due to modern diminished water tables, may have had origins at higher elevations than today. We may find it more appropriate to model rivers based on topographical characteristics rather than import them from the OS. Energy expenditure can be calculated in different ways. We could model absolute expenditure in Watts or Calories, or, as in the following examples we can calculate relative energy expenditure. We can use the cost surface to generate least cost pathways, that define the least cost route in travelling between two locations, least cost corridors which can indicate the general bounds of a likely route between two locations, or as in the following case study, we can generate so called catchment areas around sites.

Case Study 2 – Relative cost models of selected Sussex enclosures

Figure 6 gives an example of a relative cost distance model associated with geological conditions surrounding The Trundle. Here the anisotropic cost distance boundaries are defined according to the manner described by Bell and Lock (2000, 87-90). The inner yellow bounded area defines an area bounded by the minimum cost distance, the red by the mean cost distance and the green by the maximum.

Each of the boundary lines defines the same energy expenditure at any point along the line. The shape of each area is defined by the mathematical model and the values we attribute to each variable. The model assumes for example that it is easier to walk along the flat alluvial plains than it is to climb the heights of the South Downs and where superficial (drift) geology overlies bedrock (solid) geology, the bedrock is removed and the superficial used as a (?poor) proxy for soil types. From this we may make some remarks about the resources enjoyed by Neolithic society in the proximity of the enclosures.

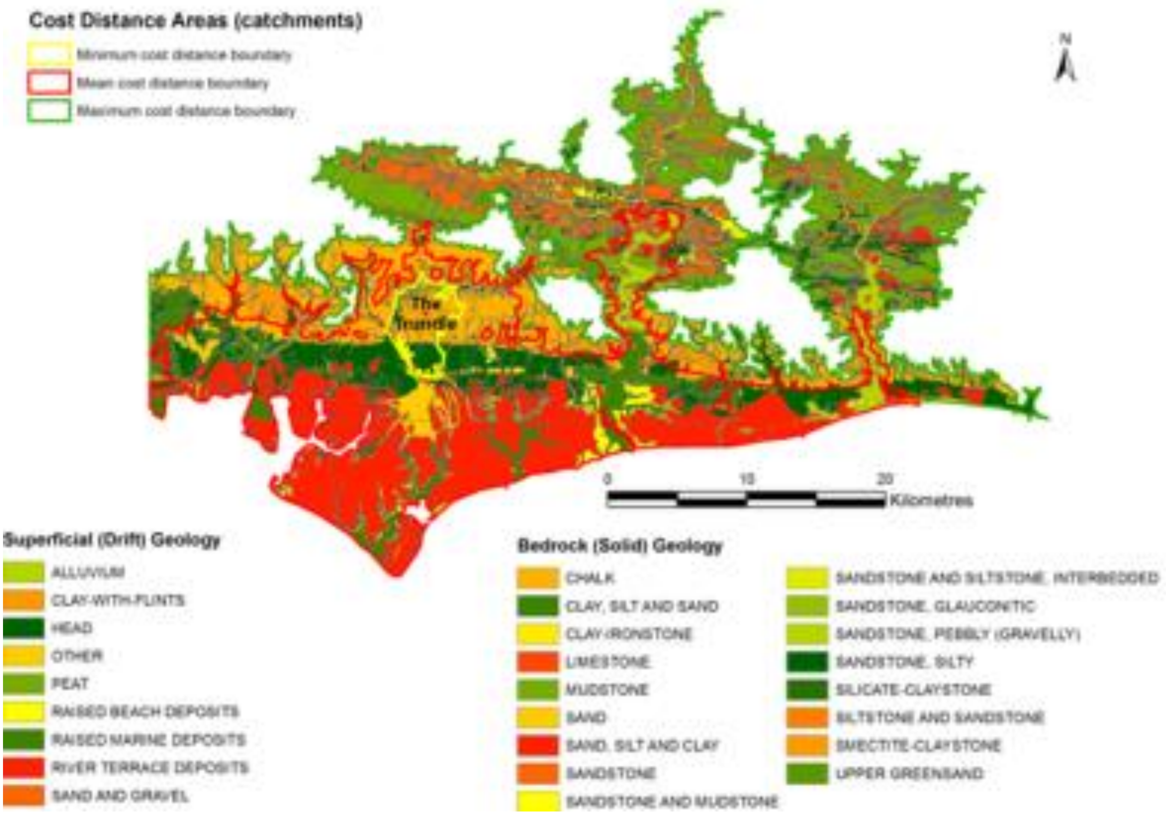

Figure 6 Cost distance (catchment area) modelling of Geological conditions surrounding The Trundle.
Spatial data: Edina Digimap, Crown Copyright/database right 2010. An Ordnance Survey/Edina supplied Service.

Figure 7 associates the cost distance areas around Whitehawk Camp with the distribution of possible early Neolithic indicators in the form of leaf-shaped arrowheads, polished axes, pits, lithics and ceramic find spots. This is a speculative leap perhaps in assuming such were contemporary with Whitehawk causewayed enclosure and introducing the normal bias associated with the archaeological record, which in this area is perhaps as much driven by modern commercial developments, PP15, and the consequent quality of the archaeological record. Nevertheless, on a national scale, where such characteristics associated with Whitehawk are later compared with other enclosures then some useful conclusions may be drawn.

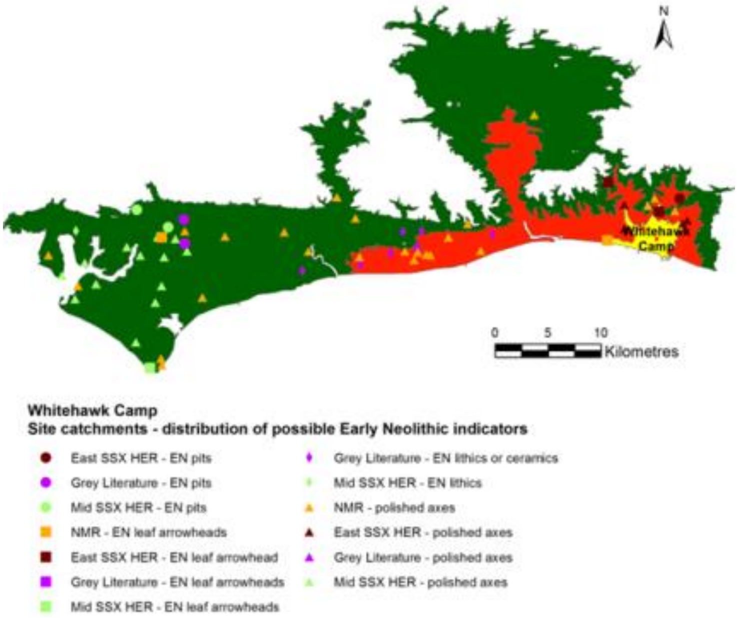

Figure 7.
Cost distance (catchment area) modelling of Whitehawk Camp (Sussex) and the distribution of potentially contemporary indicators.
Spatial data: Edina Digimap, Crown Copyright/database right 2010. An Ordnance Survey/Edina supplied Service.

Various attempts have been made to associate 'areas' with causewayed enclosures. From Renfrew (1973), using simple spatial distribution and associations with long barrows, the Wessex enclosures are defined as the centre of territorial chiefdoms. Later, Oswald (2001) defines 'land use territories' in terms of common topographical or hydrological characteristics. The GIS model here suggests areas based on the human effort required to access them and the three bounded areas may represent zones of different association. The inner zone where Neolithic activity might be strongly and directly associated with the influence and social functions of the enclosure, a second zone, perhaps the area of a modern parish or large town, where the land was relatively easily accessible and may have exploited to support Neolithic activity in or around the enclosure and a third zone where the influence of the enclosure becomes weaker. This suggests of course that the enclosures were the central place of early Neolithic society, but that's a consideration for another day.

Summary

If we understand and accept the limitations of GIS, use the GIS to answer specific questions (rather than undertake a high-tech fishing trip) and avoid an interpretation reliant on the apparent precision of the output, we may be able to overcome some of the reservations expressed by Tilley and Cummings at the start of this contribution. It is somewhat unfortunate that the technique can be so hard to deploy. GIS systems can be awkward and tiresome to learn, using them for archaeological purposes beyond simple presentation can involve detailed and lengthy processes which can be time consuming and subject to error: even on a modern computer some of the models involve many millions of calculations and can take several hours to run. The mapping data and the Lidar data required to produce the DEM, can be expensive to obtain. If the free sources available for non-commercial purposes at universities etc. aren't available to the user then this becomes prohibitive. It is possibly these practical problems that restrict the use of GIS, rather than its potential.

Dave Durkin

Bibliography

Bell, T. & G. Lock (eds.), (2000). *Topographic and cultural influences on walking the Ridgeway in later prehistoric times*: IOS Press.
Bradley, R., 1993. *Altering the earth : the origins of monuments in Britain and continental Europe,* Edinburgh: Society of Antiquaries of Scotland.
Cummings, V., 2009. *A view from the west : the Neolithic of the Irish Sea zone,* Oxford: Oxbow.
Cummings, V., C. Henley & N. Sharples, 2005. The chambered cairns of South Uist, in *Set in stone : new approaches to Neolithic monuments in Scotland*, eds. V. Cummings & A. Pannett Oxford: Oxbow, 117
Fisher, P. F., 1994. Probable and fuzzy models of the viewshed operation, in *Innovations in GIS*, ed. M. F. Warboys London: Taylor and Francis, 161-175.

Gillings, M. & D. Wheatley, 2001. Seeing is not believing: unresolved issues in archaeological visibility analysis, in *On the good use of geographic information systems in archaeological landscape studies*, ed. B. Slapsak Brussels European Union, 25-36.
Ingold, T., 2000. *The perception of the environment : essays on livelihood, dwelling and skill,* London: Routledge.
Llobera, M., 2007. Reconstructing visual landscapes. *World Archaeology,* 39(1), 51 - 69.
Lock, G., 2003. *Using Computers in Archaeology - towards a virtual past,* London: Routledge.
McGwire, K., A. Napolean, A. Chagnon & C. Carfas, 1996. Empirical and Methodological problems in Developing a GIS Database for Yanomamo Tribesman Located in Remote Areas, in *Anthropology, Space, and Geographic Information Systems*, eds. M. Aldenderfer & H. D. G. Maschner Oxford: Oxford University Press, 97-106.
McManama-Kearin, L., 2013. *The use of GIS in determining the role of visibility in the siting of early Anglo-Norman stone castles in Ireland*.
Mercer, R. & F. Healy, 2008. *Hambledon Hill, Dorset, England. Excavation and survey of a Neolithic complex and its surrounding landscape.,* Swindon: English Heritage.
Ogburn, D. E., 2006. Assessing the level of visibility of cultural objects in past landscapes *Journal of Archaeological Science,* 33, 405-413.
Oswald, A., C. Dyer & M. Barber, 2001. The creation of monuments : neolithic causewayed enclosures in the British Isles, Swindon: English Heritage.
Renfrew, C., 1973. Monuments, mobilization and social organization in neolithic Wessex, in The explanation of culture change, ed. C. Renfrew London: Duckworth, 539 - 558.
Robinson, D., R. Milner-Gulland, J. Manley & D. Kemp, 2013. *The geology and scenery of the South Downs National Park,* Lewes: Sussex Archaeological Society : distributor Sussex Archaeological Society.
Tilley, C. Y., 1994. *A phenomenology of landscape : places, paths, and monuments,* Oxford ; Providence, R.I.: Berg.
Tilley, C. Y., 2010. *Interpreting landscapes : geologies, topographies, identities,* Walnut Creek, Calif.: Left Coast Press.
Wheatley, D. & M. Gillings, 2002. *Spatial technology and archaeology : the archaeological applications of GIS,* London: Taylor & Francis.
Whittle, A. W. R., F. Healy & A. Bayliss, 2011. *Gathering time : dating the early Neolithic enclosures of southern Britain and Ireland,* Oxford: Oxbow Books.
Whittle, A. W. R., J. Pollard & C. Grigson, 1999. *The harmony of symbols : the Windmill Hill causewayed enclosure, Wiltshire,* Oxford: Oxbow Books.