ipaast-czo case study: Wiltshire

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Figure 1 Location map of the Wiltshire case study, UK

1. The Estate and the farmer / landowner:

About the place, including any interesting history, general background, and who is currently managing it.

The study area comprises agricultural land, parts of which are owned and managed by the National Trust and parts of which are privately owned and managed by two Wiltshire farms. The agricultural datasets used in this case study were generously made available by both Wiltshire farms, who also farm the National Trust land through tenancy agreements. Due to the sensitive nature of the archaeology of the general area these farms wish to remain anonymous – the location of the farmland is therefore not directly referred to here.

The agricultural land comprises shallow soils over chalk bedrock typical of undulating chalk downlands of the south coast. Elevations range between 80m –110m aOD with frequent occurrence of dry valleys. Documentary evidence suggests that the study area was already under intensive open-field cultivation at least from the late medieval period (RCHME 1979). From the late 17th to 19th centuries, parts of the area were subsumed within a larger landscaped estate which resulted in the widespread planting of tree-clumps across the fields for their aesthetic value. In the late 19th century the land was given over to increasing military use for manoeuvres and temporary camps, culminating in the construction of a military light railway and associated depot in the early 20th century. Largely decommissioned by the 1930s, only the rail embankment survives to this day. Prior National Trust ownership, the land was owned and farmed privately before, during and shortly after the Second World War. Since the 1970s the farmland is bisected by a dual carriageway running east–west.

In 1986, National Trust lands within the study area were included in a wider designation of UNESCO world heritage status listing on account of its location within a larger, internationally recognised, prehistoric ceremonial landscape.

2. Further stakeholders in land management at the Wiltshire case study farms:

(Including archaeologists and heritage management agencies interested in the land, community groups, environment agencies, etc.)

Historic England are custodians of a range of scheduled monuments listed within the study area and have undertaken recent surveys across the area (Bowden *et al*. 2015). Several Universities from within the UK and the EU are also involved in ongoing fieldwork and research within the study area (Gaffney *et al*. 2022), as well as in adjacent areas (Gaffney *et al*. 2012, 2018; De Smedt *et al*. 2022, Parker Pearson 2020, 2022). The Highways Agency also recently commissioned archaeological investigations on account of ongoing ameliorations to the dual carriageway (Wessex Archaeology 2017 – 2018).

3. Current land use:

(For example: farming practices, tourism, etc.)

Arable farming (typically winter wheat, peas) is the predominant land use type throughout the study area but includes intermittent use of fodder/forage crops such as turnips. Some National Trust fields have been recently reverted to chalk grassland and are grazed. Non-vehicular public access for recreational purposes has been granted by the National Trust on the farm tracks and disused railway embankment north of the dual carriageway on their land.

4. What we know about archaeology on the farm:

Any background on the significance of local archaeology, prior research etc.

The study area has a long history of archaeological investigations and research (RCHME 1979; Richards 1980; Cleal *et al*. 1995; Exon *et al*. 2000; Bowden *et al*. 2015) and contains over 50 scheduled ancient monuments. Known archaeological features were already documented by early antiquaries and/or since located and recorded by non-invasive investigations such as aerial photography. Recent geophysical and landscape-based investigations (Gaffney et al. 2018; Roberts *et al*. 2017) have also contributed to the ever-increasing body of knowledge relating to these fields. Most recently, a university led study revealed that a series of usually large pit-like features formed part of a massive, landscape-scale circuit, which most probably is associated with other late neolithic activity in the area (Gaffney *et al*. 2020).

Principle prehistoric monuments and features across the study area include:

- From the Neolithic – two long barrows (earthen mounds), a processional avenue, a henge monument (ceremonial enclosure) with an associated feasting-pit, and several lithic scatters.
- From the Bronze Age – 50 documented round barrows (earthen mounds) predominantly bowl but includes two pond types). Some are isolated examples but many are clustered in small linear arrays, with some located near earlier neolithic monuments.
- From the Late Bronze Age/Early Iron Age – linear field boundaries and enclosures represented by earthen banks and/or ditches running over large distances and generally accepted to relate to early land management practices.

While many of these monuments have been damaged or completely levelled by subsequent activity (relating to agriculture, infrastructure, or military), many monuments remain extent within the farm landscape.

Figure 2 Case study area outline (in red) with adjacent archaeological prospection data – University of Ghent FDEM conductivity data (De Smedt et al. 2022 and Gaffney et al. 2018).

5. How precision agriculture is being used:

Past data collections, methods being used, if any – or ambitions to do this if it's not already happening.

Frequency domain electromagnetic (FDEM) method soil scanning (once-off) has been employed by both farms to gather information on soil texture. In both cases, soil scanning surveys were undertaken by a service provider, Soyl Ltd. Scanning was followed up with physical soil sampling at strategic locations for ground truthing and nutrient mapping purposes. The results are used to create management zones for the use of variable rate techniques such as seeding and fertilising. Other technologies used include machine guidance for vehicles and in the case of one farm, the trial of a combine yield monitor during two harvest cycles. Economic considerations presently deter further use of precision agriculture technologies.

6. Management Challenges:

What the main land management problems are, especially with an eye to improving sustainability.

Main land management challenges within the study are:

- reconciling farming practices with a high volume of archaeological remains within areas of arable crops
- reconciling farming practices with environmental sustainability goals (e.g. increased biodiversity, reversion to grassland/pasture), especially on tenanted land

- discouraging/controlling/restricting public access to private land (metal detectorists, fringe enthusiasts)
- pressures on local land and wildlife exerted by national infrastructure projects (e.g. increased traffic, land reclamation (temporary and permanent), contamination and/or pollution (land, air, water), potential changes in ground water levels, damage to or destruction of farmland and/or archaeological remains)

7. Sources of existing data:

Archival data or other existing data you were able to access, including previously collected precision agriculture data.

- Scheduled Monuments GIS Data: https://historicengland.org.uk/listing/the-list/data-downloads
- Environmental Agency Lidar data: https://environment.data.gov.uk/DefraDataDownload/?Mode=survey
- Aerial Archaeology Mapping Explorer: https://historicengland.org.uk/research/results/aerial-archaeology-mapping-explorer/
- Gaffney *et al*. 2020, Supplementary Data, 1. Feature Gazetteer https://intarch.ac.uk/journal/issue55/4/sup1.html

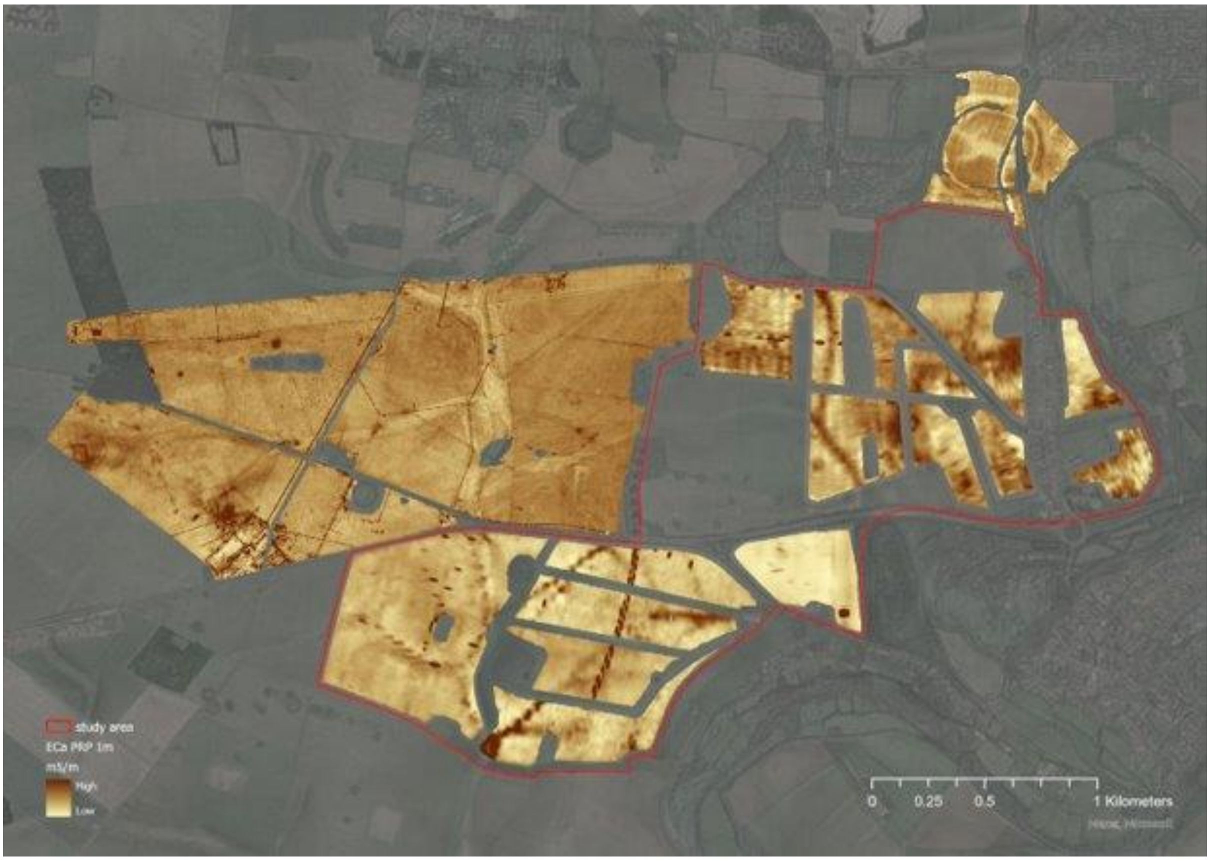

Figure 3 Case study area (red outline) with agricultural FDEM conductivity data collected by Soyl Ltd, side-by-side with archaeological prospection data – University of Ghent FDEM conductivity data (De Smedt et al. 2022 and Gaffney et al. 2018).

8. New data collected for the case study:

The data you collected… in summary with a pointer to the data archive.

Precision agriculture data made accessible by Wiltshire farms:

Farm 1 (CF):

- FDEM soil scanning data (unprocessed) in open text file format, collected 2018/19
- Combine yield monitor data (unprocessed) in proprietary format, collected 2018/2019
    - Combine yield monitor data (unprocessed) in open text file format (converted 2023)
    - Combine yield monitor data (unprocessed) gridded in geo-tiff format (interpolated 2023)

Farm 2 (WA):

- FDEM soil scanning data (unprocessed) in open text file format, collected 2011/2011

Data archive: Zenodo open data repository https://doi.org/10.5281/zenodo.7867315

Case study – preliminary results presented at CAA 2023 Amsterdam:
https://2023.caaconference.org/wp-content/uploads/sites/29/2023/04/abstract_book_v13.pdf

Figure 4 Case study area (red outline) with agricultural FDEM magnetic data collected by Soyl Ltd, side-by-side with archaeological prospection data – University of Ghent FDEM conductivity data (De Smedt et al. 2022 and Gaffney et al. 2018).

9. Insights from joint analysis and interpretation:

Interim results and anything you've learned from the data you've collected from both an archaeological and precision agricultural perspective.

The fundamental goal behind this case study was to explore how easy it is to integrate precision agriculture data into archaeology workflows.

FDEM Soil Scanning data:

Integration: We found that agricultural FDEM soil scanning data were very accessible as they were delivered in an open text file format. Unfortunately, a lack of appropriate metadata limited its full integration and usefulness.

Preliminary results: Despite the relatively coarser sampling resolution of the agricultural data, we were able to trace the outline of more conductive soil deposits along the dry valleys running throughout the study area. These indicate possibly thicker soil deposits with higher moisture levels, potentially preserving paleoenvironmental or even settlement evidence, as paleochannels (when originally active), will have potentially attracted prehistoric settlers/activity.

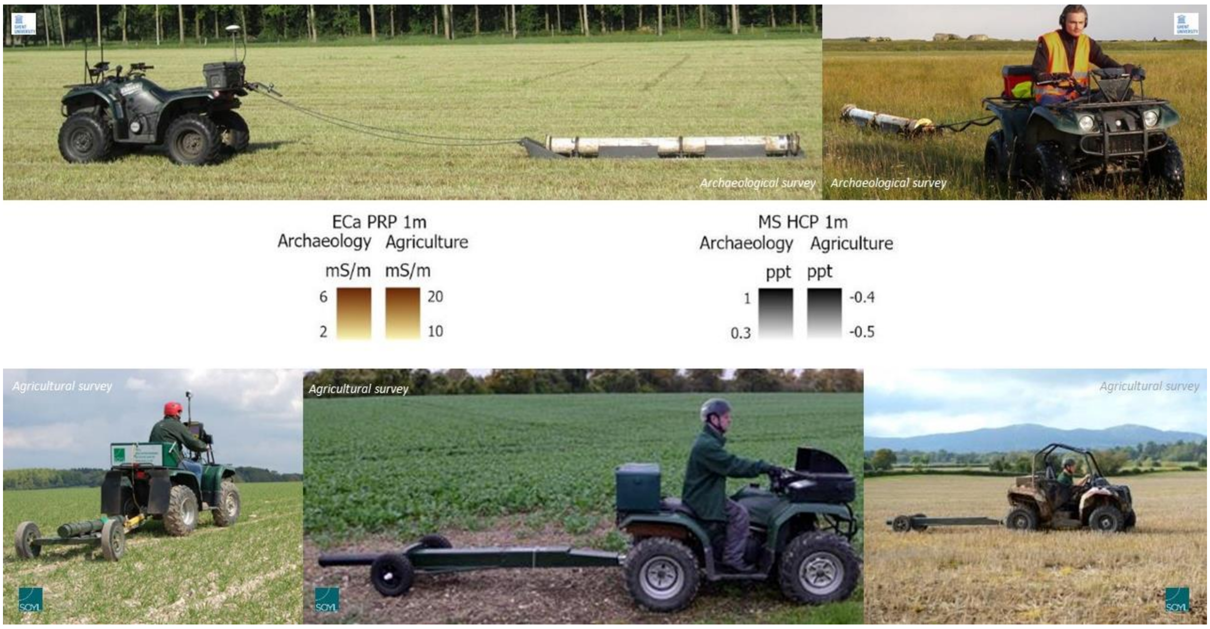

Figure 5 FDEM sensor set-up archaeological prospection (top) courtesy University of Ghent) and agriculture (bottom) courtesy Soyl Ltd. Measurements range legends illustrating measurement offsets between agricultural and archaeological datasets – conductivity on the left, magnetic susceptibility on the right.

We could also identify archaeological structure within the conductivity and magnetic susceptibility data: a large circular, pit-like anomaly *c*. 20m in width, which has been previously documented by aerial photography and geophysical survey. A recent study (Gaffney *et al*. 2020) has demonstrated this feature most probably belongs to a monumental landscape feature of Neolithic origins which potentially holds important paleoenvironmental and dating evidence that relates to prehistoric activity in the immediate area.

However, while this looks promising, limitations to its full archaeological use have also been identified. When comparing measurement ranges, we can see a large offset between the agriculture dataset and archaeological dataset (conductivity and magnetic susceptibility). The offset does not relate to variations in temperature during the day, or any other another obvious source. It remains unexplained.

We are currently working with the service providers to identify its cause. If the source can't be accounted for, these agricultural data can't be properly compared like-for-like with the archaeological conductivity data, a situation not helped by an absence of metadata (e.g. basic information relating to acquisition methods and to survey timings (season, weather).

Conclusion: The agricultural FDEM data (conductivity and magnetic susceptibility) is good quality data which we believe is potentially very useful to archaeology research and management if accompanied by appropriate metadata.

Yield monitor combine data

Integration: We found that the yield monitor data were very inaccessible as they were delivered in proprietary format. Again, as above, it unfortunately lacked the appropriate metadata for full integration and use, even after conversion into an open format text file.

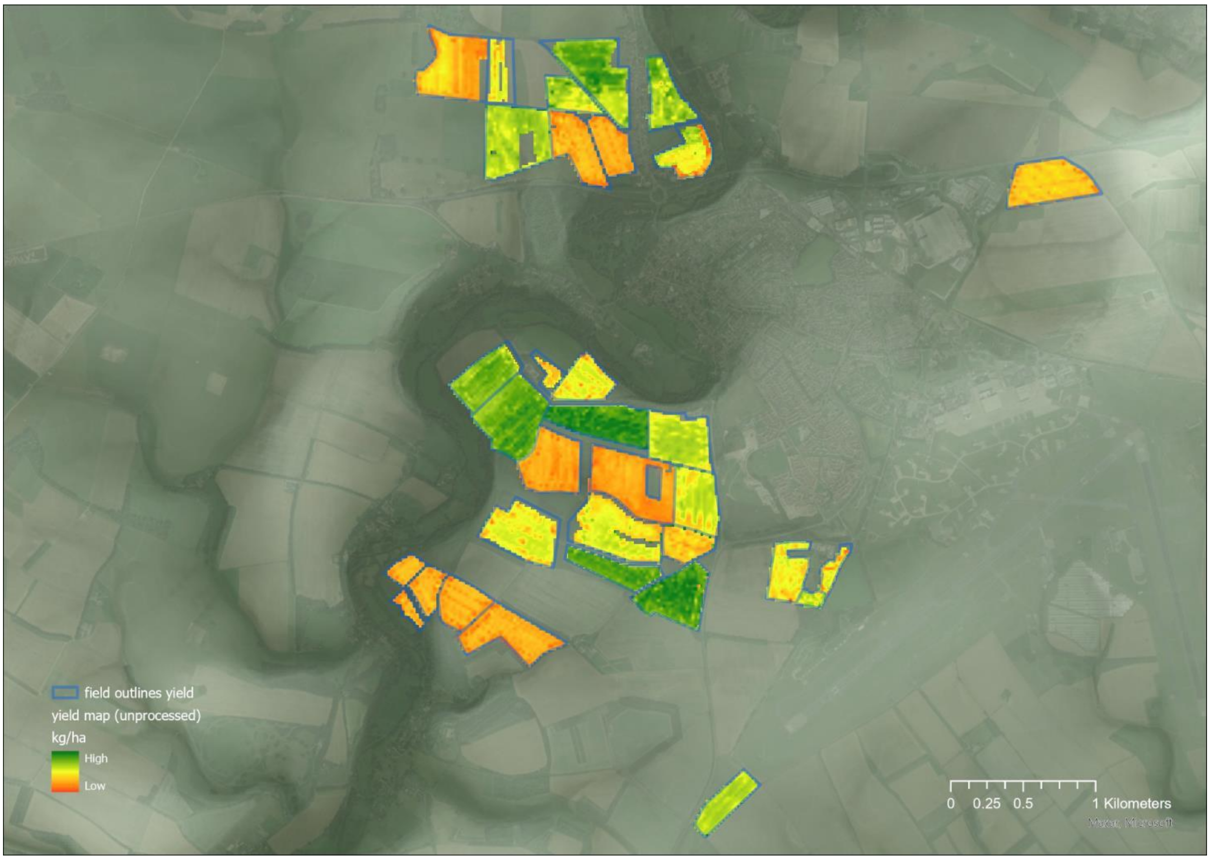

Figure 6 Combine yield monitor data (unprocessed) displayed over topographically shaded aerial photography (source: Maxar – Microsoft)

Preliminary results: After conversion to an open format text file and integration with archaeological information, these raw data remained to noisy to be of immediate use. Despite high levels of noise evident in the raw yield data, preliminary exploration of the data was undertaken with statistical analysis in relation to fields with archaeological potential:

A basic variogram analysis using was carried out (see Figure 7) – initially with raw data on the left, and subsequently on a smoothed (de-spiked) data on the right). Variogram functions for fields with low and high archaeological potential both display a positive spatial correlation, without reaching the sill/saturation point. However, the variogram illustrates higher variability at lower distances between points for low archaeology fields (in red). This difference is repeated in the variogram graphs on the right for smoothed dataset, albeit with a nugget/noise close to zero, and is interesting as it is counter-intuitive to expectation. We had presumed the fields with more archaeological disturbance would show the greater variability at smaller lags. It may be that the variogram plots for high archaeological potential are reflecting the results of more farm management practices over time or archaeological remains are present on soils with less spatial variability.

Conclusion: This difference between variogram plots, remains to be investigated and tested further (e.g. also for the effects of topography on results), especially on a properly cleaned dataset, as it could serve as a method of identifying area of high archaeological potential – it serves here mainly to highlight the potential of exploring other precision farming data, such as yield.

Again, a total absence of metadata accompanying the yield data was noted – including no basic information regarding which make of yield monitor had been employed, or even which crop were being harvested – effectively limiting integration and analysis.

It was also noted that cleaning yield monitor data is a complex process that requires technical expertise from the agricultural sector.

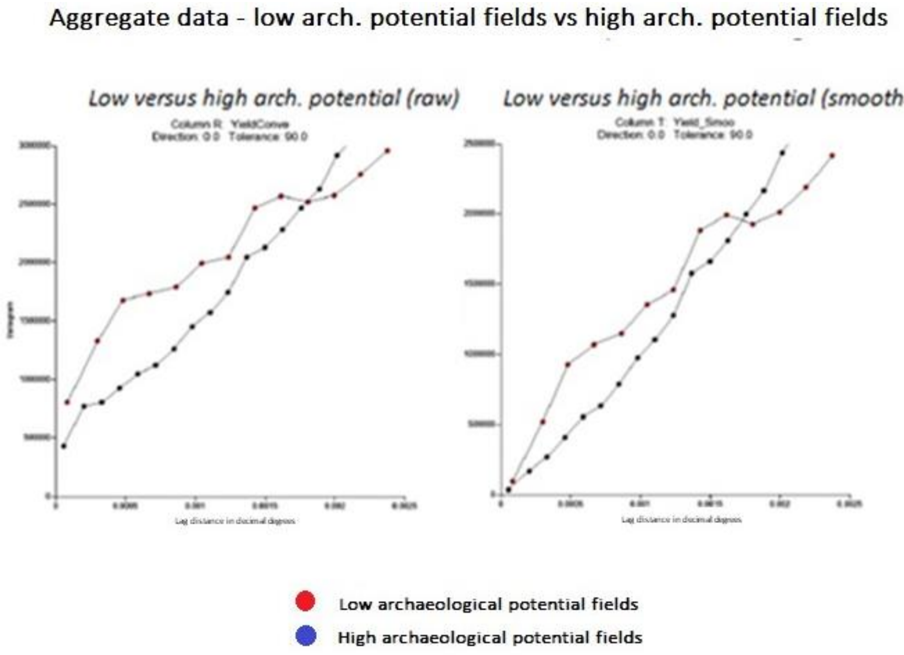

Figure 7 Variograms of aggregate data – fields with low archaeological potential contrasted with fields with high archaeological potential. Raw data on the left, smoothed (de-spiked) data on the right.

Variogram functions for fields with low and high archaeological potential both display a positive spatial correlation, without reaching the sill/saturation point. However, the variogram illustrates higher variability at lower distances between points for low archaeology fields (in red).

10. Soil Health and Heritage futures:

How the data you collected could be used for sustainable management. What further data would be needed.

The large-scale, low-resolution agriculture datasets encountered in the case study can have a broader relevance (especially in this case EM data). It is a massive resource for land management (inc. archaeology) as there is lots of data, which covers very large areas. For heritage management it could provide archaeological relevant information in areas where we currently have simply no data.

However, coordination in work practices between domains is needed, as agricultural data will only be fully integrate-able if accompanied by appropriate metadata, open formats and expertise.

How we achieve this between domains is work-in-progress, with many open questions (such as how exactly is archaeology expressed in the farming data?) remaining. We hope case studies such as these helps raise awareness of the potential of farming data with the aim of encouraging collaboration between archaeology and agriculture.

11. References:

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