ipaast-czo case study: The Rinconada Estate.

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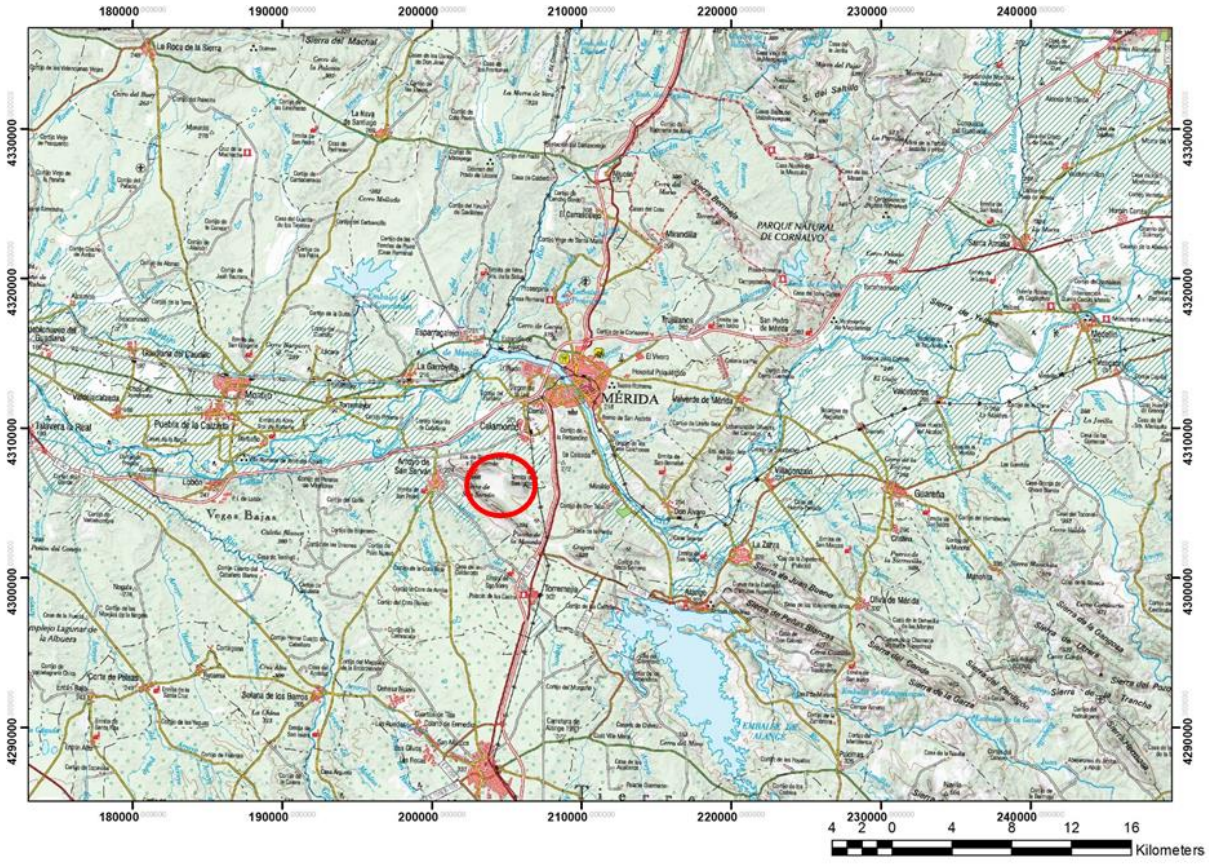
1.-The Estate and the farmer / landowner:

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

The Rinconada estate is located in the municipality of Calamonte, in the province of Badajoz, about 8 kilometres southwest of the city of Mérida. It extends over 450 hectares of mountain, pasture and meadow lands. The site owes its name (literally “the corner”) to the local topography, as it encompasses a valley closed on all sides except the southeast. This type of formation is characteristic of the residual reliefs composed of quartzite and slate, forming small mountain ranges that dominate the Guadiana valley. The estate is a family business run by María Pía Sánchez and her sisters.



Location of the Rinconada estate close to Merida in the province of Badajoz, Spain.

2.-Further stakeholders in land management at Rinconada estate:

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

From an environmental point of view, the Rinconada Estate is part of a zone of special protection for avifauna and is integrated in the *Natura 2000* network. This is managed by the Government of Extremadura at a regional scale.
(http://extremambiente.juntaex.es/files/planes_gestion/66_PG_Sierras_Centrales_y_Embalse_de_Alange.pdf). The regional Government also has responsibility for the management, inventory and protection of its cultural heritage. Since the owner is the president of the Spanish Federation of the Dehesa, the Rinconada estate has been one of the most active partners in some research initiatives in which the Federation has been involved, especially the LIFE LiveAdapt project. This is part of the LIFE programme of the European Union, in which a multidisciplinary team of organisations from Spain, Portugal and France has been working for four years (2018-2022) to find solutions for the adaptation to climate change of extensive livestock production models in southern Europe.

The Rinconada estate is an active partner in the multidisciplinary *LIFE LiveAdapt* project, part of the LIFE programme of the European Union.

3.-Current land use:

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

La Rinconada is a sheep farm that combines the dedication of land to dehesa, pasture and forest. As a collaborating partner of the previously mentioned LIFE project, the activities of the farm have been open to the testing of innovative formulas for the management of livestock and vegetation in the face of the challenges of climate change. Topics addressed during this coordinated program are as follows:

- Role of traditional dry stone farm fencing techniques in preserving biodiversity; simultaneously a benefit for the preservation of cultural heritage.
- Adaptive grazing management.
- Productive and ecological importance of scrub in the dehesa vegetationlandscape.
- Improvement of pastures with varieties adapted to climate change.
- Water management for extensive livestock grazing.

As an additional research area, the owners of the Rinconada expressed their willingness to encourage an assessment of the potential and challenges of the cultural heritage of the dehesa within their lands. Members of the IPAAST Spanish team were authorised to develop a work program focused on the combined use of Precision Agriculture and Archaeology methods within the estate.

4.-What we know about archaeology on the farm:

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

The farm is located a few kilometres from an important Roman settlement (*Colonia Augusta Emerita*). There is abundant knowledge about the impact of the foundation of this city on the organisation of the colonial territory (Gorges and Martín, 2006; Cordero Ruiz, 2013). Numerous rural settlements dating to this period have been extensively studied, including notable examples of large and monumental *villae* (Martín, 1995). While there were no previous published references to archaeological sites from this period or any other within the farm, the owners informed us of the existence of archaeological finds in various parts of the property. Thanks to this sensitivity and interest in studying its potential historical value, the possibility of carrying out a study was raised. For the research team, the interest in exploring the synergy of archaeological and precision agriculture methods posed an excellent opportunity.

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.

Precision agriculture had not previously been used in the management of this farm. Therefore, there was no previous data to analyse. The wwners expected that new data could be useful for the management of water and grazing of sheep herds within the estate.

6.-Management Challenges:

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

The biggest challenge for the Rinconada estate is increasing aridity in land that already has very limited productive potential. The terrain is very stony, and the soils are very shallow and vulnerable. Therefore, information that allows delimitation of management zones for grazing is viewed as useful in order to maximise efficiency in the use of very limited resources. The use of remote sensing to calculate carbon sequestration capacity may represent an additional source of income.

7.-Sources of existing data:

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

Previous spatial data for the study of the Rinconada were gathered from public repositories of geographic information, specially from the National Institute of Geography (https://centrodedescargas.cnig.es/CentroDescargas/index.jsp). It included:

- LiDAR data for terrain analysis
- Derived DEM data at different scales
- Vector files containing topographic features
- Vector layers with soil and geology data
- Historical series of orthoimages from 1956 to the present

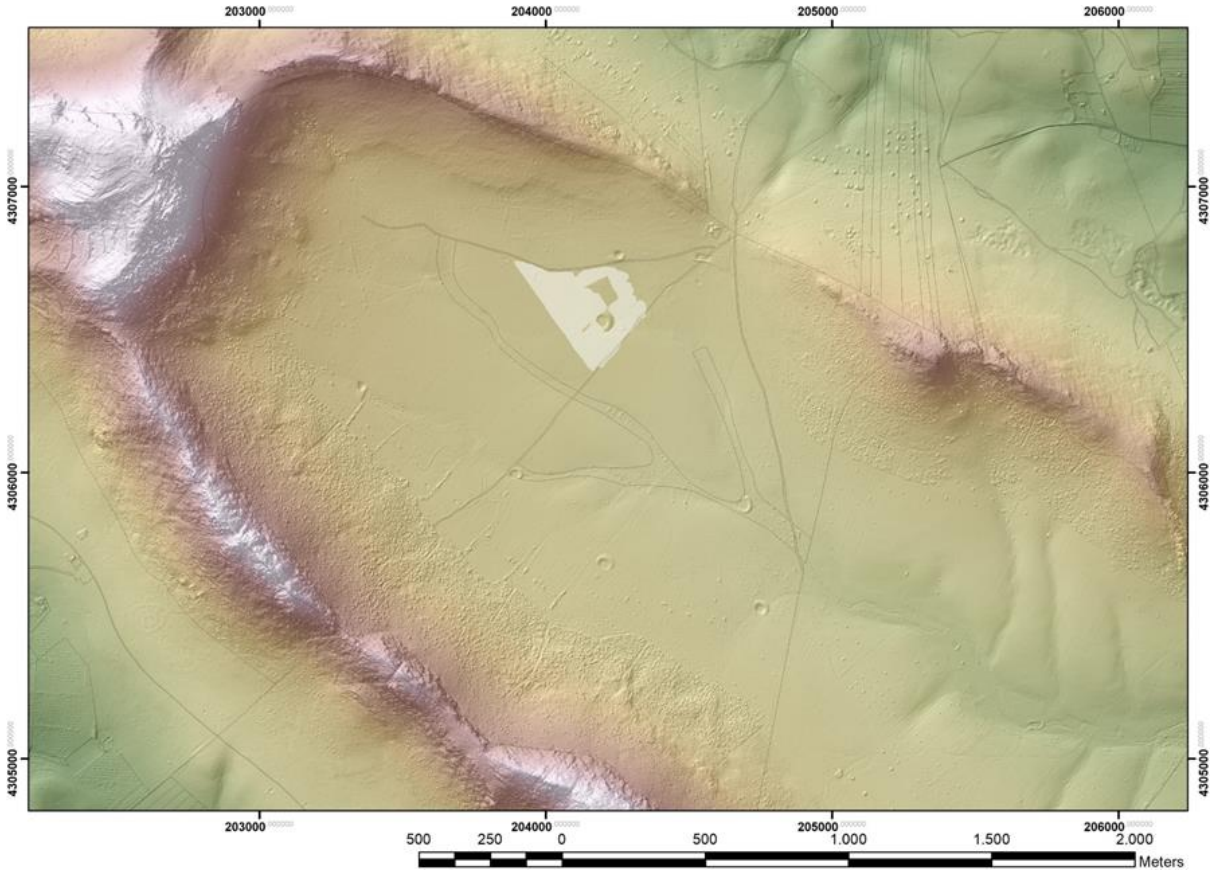
- Specific drone flights with thermal IR and multispectral data that were planned as part of the IPAAST project.

8.-New data collected for the case study:

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

The interest in testing different survey methods within the framework of the IPAAST project was motivated by three objectives:

- identifying evidence of rural life in the hinterland of the Roman colony of Augusta Emerita, with special attention to forms of resilience and diversification of agrarian activities beyond the areas of highest productivity of the alluvial plain of the Guadiana River.
- assessing the composition and depth of soils in the area in order to evaluate the representativeness of surface finds and perform a regression analysis to assess the potential distribution of arable lands in the area from Roman times to the present.
- combining geophysical methods commonly used in precision agriculture and archaeology in order to evaluate their interoperability and the complementary information they can provide.



Location of the study area within the Rinconada Estate.

Attention was focused on a sector of the estate where two elements were coincident 1) preliminary evidence suggested the estate's highest concentration of archaeological finds. 2) land plots within the estate used for grazing where LIFE Adapt experiments were undertaken. This area encompassed approximately. 6.5 ha.

Four methods for the exploration of these two elements were employed:

- Surface artefact survey. Although this method could add little to the characterization of soils in the area, it was considered essential for a clear spatial definition of areas or archaeological interest and could provide some insights into erosion. Survey procedures included the intensive coverage of the area with an interval of 10m between fieldwalkers. Every surface find was mapped in order to produce an estimation of sherd densities to define any potential area of concentrated activity (for a description of the method see Mayoral Herrera and Celestino Perez, 2009 and Sevillano Perea and Mayoral Herrera, 2015). Datasets:
    - RC_SURF01
        - 01 vector layer with the GPS track of every fieldwalker covering the survey area.
        - 02 vector layer with the xyz coordinates of every find spotted by fieldwalkers in the survey area.
        - 03 raster layer with a kernel density calculation based on file 02.
- LiDAR: available open access data were downloaded and processed using standard GIS procedures and image processing techniques specific for the detection of archaeological features (Štulara *et al.*, 2012).
- Magnetic survey with a 2-sensor gradiometer system (Grad602) by Bartington. Data sets:
    - RC_MAG
        - 01 Vector limits of survey area.
        - 02 Vector point file of vertices of survey area.
        - 03 Grid composite.
        - 04 Raster interpolation of magnetic data.
- Electromagnetic induction with a EM38Mk2 by Geonics. Data sets:
    - RC_EMI01.
        - 01 Vector limits of survey area
        - 02 Vector file of point data
        - 03 Raster interpolation of quad-phase (conductivity) 0.5m
        - 04 Raster interpolation of quad-phase (conductivity) 1m
        - 05 Raster interpolation of in-phase (magnetic susceptibility) 0.5m
        - 06 Raster interpolation of in-phase (magnetic susceptibility) 1m

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 a precision agriculture perspective.

From an archaeological perspective, research at the Rinconada Estate successfully delimited a series of sites that, although previously known by the owners, had not been the object of previous research. Integration of LiDAR analysis and surface survey allowed for very clear spatial definition. A preliminary assessment of surface finds revealed that all the sites can be dated to the Roman Imperial period. Nevertheless, the material record is extremely poor. No diagnostic pottery was found (only 1 sherd of *terra sigillata*), so the chronological definition was loosely established from the building materials (roof tiles). The only other items of this category were concentrations of local dry stone blocks, suggesting very poor preservation in some areas, while revealing the impact of recent soil removal.

Magnetic mapping with a Bartington gradiometer

In summary, it seems to be a compound of very humble agricultural facilities distributed along the bottom of the Rinconada valley. These would likely have operated as integral parts of a farm. We found no evidence of any residential complex. The small size of the structures and the scarcity and monotony of the surface records suggest that they were work areas, perhaps for livestock management. The marginal character of this space compared to the fertile river valley of the Guadiana suggests that cattle exploitation would predominate here. If confirmed, this would be significant to our knowledge of the diversity of Roman rural life in the area, expanding the picture beyond just conspicuous residential *villae* (Bowes, 2021; Herrera *et al.*, 2022).

These results may explain the results of the project's geophysical surveys, especially magnetic prospecting, which were inconclusive. Notably, despite the large area covered, no linear traces were clearly identified that could be related to the presence of structures in the subsoil.

Finally, whether these results could be considered positive for the management of this dehesa estate in the present is something that will have to be assessed more carefully once all the analysis of all the information collected has been completed. Broadly speaking, we can point to two immediate outcomes. The first is the possibility of mapping in more detail the areas with the greatest potential for grazing. The second is the possibility of establishing precautionary zones around sensitive areas in order to avoid alterations to the terrain that could further damage key archaeological areas. This work of preservation could eventually provide a path to valorization of the archaeological sites with a view to rural tourism activity on the farm, something in which the owners are interested.

10.-Soil Health and Heritage futures:

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

The data collected to date will be useful for assessing the impact of erosion on the landscape of the dehesa and its potential restoration through the introduction of pasture management systems and more sustainable stocking strategies. In order to get a more complete understanding of these processes, it will be necessary to develop geomorphological studies to dissect the "soil archive" in the

sedimentation zones. This record must be complemented with dating and sedimentological studies that allow us to reconstruct the global dynamics of this landscape, its milestones and oscillations based on climatic variations and the intensity of anthropic pressure at different moments over time. It will also require an evaluation of the carbon sequestration capacity and, in general, the evaluation of remote sensing methods for monitoring the health of these forests.

The information collected is also essential to create an inventory of cultural elements of the dehesa from prehistory to the recent past. Private initiatives related to archaeology, promoted by the owners of the dehesa estates, likely represent the biggest challenge to heritage management. It is evident, on the one hand, that the heritage that exists within these farms is part of the public domain. Therefore the owners have a duty to protect and preserve it. It is no less true that the current policies of the public administration are essentially punitive in nature, and that there are few incentives for them to see the presence of archaeological sites as a potential benefit. It would therefore be desirable that, as occurs with other EU policies for agricultural management and environmental protection, incentives would be developed to reward the work of custody and enhancement of cultural heritage on these private lands.

EMI mapping with a EM38Mk2 using a tractor towed system

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