

Landscapes of the Past: The Maremma Regional Park and the Grosseto Coastal Belt. Methodology and Technical Procedures

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Abstract. A few methodological and technical aspects regarding the use of historic cartography in a GIS environment and in relation to research on landscapes of the past are discussed. More specifically, the problems and the development of contextualized procedures for the acquisition and georeferencing of the Catasto Leopoldino of the Grosseto area (dating to the 1820's) are examined. Based on the need for accurate high quality acquisition and georeference data, a few examples of analysis are given of the historic landscape through the integration of different sources.

Keywords: Grosseto, Maremma Regional Park, historical cartography, data acquisition, georeferencing

1. Introduction

The work presented here forms part of a research project which is the result of a collaboration between the Department of Archaeology and History of the Arts and LIAAM (the Laboratory of Computer Science Applied to Medieval Archaeology) of the University of Siena, The State Archive of Grosseto and the MEDCORE (the European project for Mediterranean Coast-River Ecosystems). The main objectives of the research project are the following: the development of a methodology for the study of ancient landscapes using different source typologies integrated in a GIS environment, with special reference being given to historical cartography and aerial photographs (recent and historical); application of this methodology for a greater in depth understanding of landscape transformation processes and the historical evolution of settlement strategies in the Grosseto coastal belt. Although some of the preliminary results have been presented on other occasions (De Silva and Pizziolo 2003a; 2003b; 2004), research is still underway and this paper will focus on a few technical and methodological aspects. In particular the methodology and technical procedures for the use of historical cartography in a GIS environment will be discussed. Reference will be mainly made to the Catasto Leopoldino, a geometric cadastre undertaken between 1817 and 1835 for the whole territory of the Granducato of Tuscany. The case study presented here refers to the Maremma Regional Park and the Grosseto coastal belt in southern Tuscany.

2. Integrating Historical Cartography in a GIS

The use of historical cartography in a GIS environment involves several different methodological and technical aspects:

- the philological analysis of historical documentation and cartography;
- the techniques of reproduction and digital acquisition of historical cartography;
- the methodologies for georeferencing historical cartography;
- the interpretation, acquisition and organization of thematic layers;
- the techniques of analysis, representation and communication.

Let us illustrate a few of these aspects.

2.1 Reproduction

With regard to the reproduction and digital acquisition of historical cartography it is necessary to make a few simple preliminary considerations.

Maps are large format documents created to be viewed at close hand. This implies a series of technical problems that derive essentially from the size of the document, the need for a high resolution reproduction in order to facilitate legibility of details, and the constraint to preserve and protect fragile historical documents against damage.

For the digital reproduction of historic maps one of three main procedures can be adopted: the photographic reproduction and subsequent scanning; the direct scanning of the original map; use of a digital camera. The third option has been discarded since the resolution reached with this kind of device at an affordable cost proves insufficient for the reproduction of large format documents. We will, therefore, concentrate on illustrating the advantages and disadvantages of the first two procedures.

Perhaps the most important advantage of a photographic reproduction is the low risk of damage to the original document. However, the photographic procedure is a multi-

step process which is both time consuming and costly and the larger the format of the document the lower the effective resolution output will be.

The main advantages of direct scanning are its high effective resolution, accurate chromatic output and the fact that it is a one-step process. Nevertheless, devices are expensive, especially the large format flatbed scanners, whereas the more affordable large format roll scanner increases risk of damaging the documents.

Results from the experimental application of both procedures to the same medium scale map (1:60,000), 60 x 80 cm. in size, have enabled a technical comparison.

In the first case, the map has been photographed with a 6 x 7 slide film that has been subsequently scanned at 2400 dpi. The final result has an effective resolution of less than 200 dpi and a pixel ground size of approximately 8 m. In the second case, the map has been scanned directly at 300 dpi (corresponding to the effective resolution) with a 5 m. pixel ground size. From a comparison of the final images (Fig. 1) it is apparent that the image obtained with the direct scan shows greater detail and has a more accurate chromatic response.



Fig. 1. Comparison of detail between images obtained by photographic (on the left) and direct scanning (on the right) procedures.

2.2 Georeferencing

Georeferencing historical cartography generally involves the following series of steps:

- Preliminary image processing
- Choice of reference cartography
- Identification of control points
- Choice of geometric transformation methods
- Geometric correction and georeferencing
- In a few instances blocking out and mosaicing maps

Two different kinds of deformation in historical maps exist: those that are homogeneous throughout the entire map which can be corrected by global geometric transformations (either projective or polynomial); and those that are unhomogeneous or irregular, often conservation and damage related, which can be corrected by local transformations, also known as warping techniques.

3. The Procedures Adopted for the Catasto Leopoldino of Grosseto

Within the context of our research on historic landscape settings and transformation processes in the Grosseto area, it was decided to integrate the information gained in the GIS with data from historical cartography. The Catasto Leopoldino has been selected due to its extensive coverage of the study area, wealth of detail and geometric accuracy. Furthermore, it refers to a period preceding the significant landscape transformations which occurred as a result of human intervention from the 1930's to the present day. For this reason the Catasto Leopoldino constitutes a trait d'union or bridge between present day and earlier landscapes which aid us in the interpretation and georeferencing of older maps.

3.1 Reproduction of the Catasto Leopoldino of Grosseto

The main objectives of the reproduction of the maps of the Catasto Leopoldino in the State Archive of Grosseto was to set up a quick low cost procedure, to obtain high resolution images with minimum distortion and without any risk of damage to the original maps. The direct scanning appears to provide the best results, as we have already mentioned above, although the large format roller scanner may run the risk of damaging historic manuscript maps. Based on positive tests carried out on current maps to overcome these risks, a simple yet efficient solution was adopted, namely the insertion of the documents in a transparent protective acetate 'pocket' before running them through the scanner. With this procedure it has been possible to safely scan approximately two hundred maps in a relatively short space of time. With a 300 dpi resolution, extremely detailed images have been obtained (Fig. 2) with good contrast and chromatic response and with a virtually imperceptible loss of brightness that can, moreover, be easily corrected.

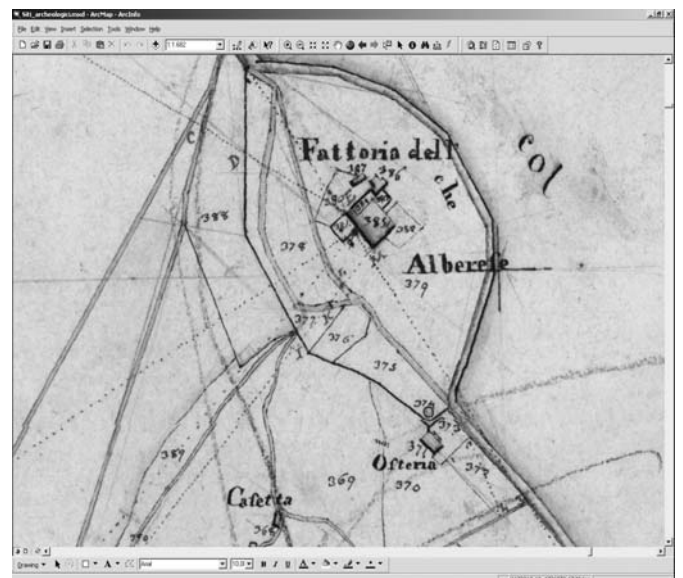


Fig. 2. Detail (approx. 11.5 x 7.5 cm.) of the digital reproduction of the maps (1:5,000) of the Catasto Leopoldino of Grosseto obtained through direct scanning (300dpi).

3.2 Georeferencing the Catasto Leopoldino of Grosseto

Georeferencing implies a geometric transformation (global or local) and correct positioning within a known coordinate system. In other words, a controlled distortion and a roto-translation of the historic map is applied in order to fit a recent map with a known reference system. This is usually possible by identifying control points in both the source and target maps and by applying the appropriate transformation. One of the problems encountered with the Catasto Leopoldino of the Grosseto area was that several maps, due to territorial changes over the last two centuries, lacked recognizable control points making it impossible to accurately georeference them.

In the Catasto Leopoldino, every *Comunità* (i.e. the administrative subdivision corresponding to the municipal district) has its own local reference grid that is reproduced on every individual map. By georeferencing these grids, it is therefore possible to georeference all the cadastre maps, even those lacking in ‘real’ or ‘actual’ control points. The problem which now arises is how to accurately reconstruct and position a historic local grid within a current known reference system. The technical procedure developed for georeferencing the Catasto Leopoldino maps can be summarized as following:

- preliminary image processing (trimming, straightening, etc.).
- local geometric correction of cadastral maps based on the topographical grid (warping) to avoid unhomogeneous distortion.
- georeferencing several of the cadastral maps throughout the use of identified control points on the reference maps.
- reconstruction of and georeferencing the historic topographical grid of Grosseto based on previously georeferenced maps.
- georeferencing all the cadastral maps using the crosses of the reconstructed grid as the control points.

After the preliminary image processing, each single map has been warped using a local transformation method so that the original grid conforms to a regular one. This procedure eliminates any irregular distortion of the support.

Only a few cadastral maps have good control points identifiable on the reference maps that allow a high level of geometric accuracy. A few of these, with a good relative distribution in the Grosseto area, have been georeferenced based on the control points using the global transformation (polynomial) method. The target reference system is the Italian national grid system (also known as Gauss-Boaga) based on the Roma 1940 datum (International Ellipsoid, orientation Monte Mario, Rome, Transversal Mercator projection).

The grid system used in the Catasto Leopoldino has a module of 1000 Florentine braccia (i.e. 583.696 m.) (Catasto della Toscana 1819) and in the case of Grosseto its origin is the bell-tower of the church of San Pietro, Grosseto. This information is sufficient to reconstruct and execute the preliminary positioning of the grid. However, the grid orientation does not match the orientation of the Italian national grid system since the projection methods and grid origins differ.

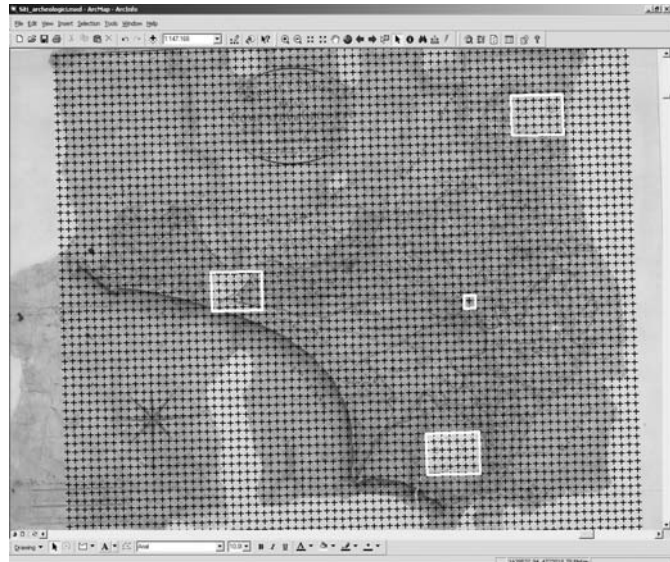


Fig. 3. The grid system of the Catasto Leopoldino of Grosseto georeferenced using a few of the previously georeferenced maps (white rectangles); in the background the index map (Quadro d'insieme) of the same cadastre.

In order to obtain more accurate orientation and to georeference the Catasto Leopoldino grid through the global transformation (polynomial) method, the grid crosses reproduced on a few of the previously georeferenced maps (underlined by white rectangles in Fig. 3) were used as target control points. In this way it has been possible to obtain a general framework for the whole territory of Grosseto with a high level of accuracy (Fig. 3).

Thanks to this procedure georeferencing of all the maps was, therefore, made possible, including those lacking any ‘actual’ control points. This can be achieved through a ‘soft’ global transformation method, utilising the reconstructed grid as target control points. Errors are generally limited to within ten meters for maps at a scale of 1:5,000. At this point a greater

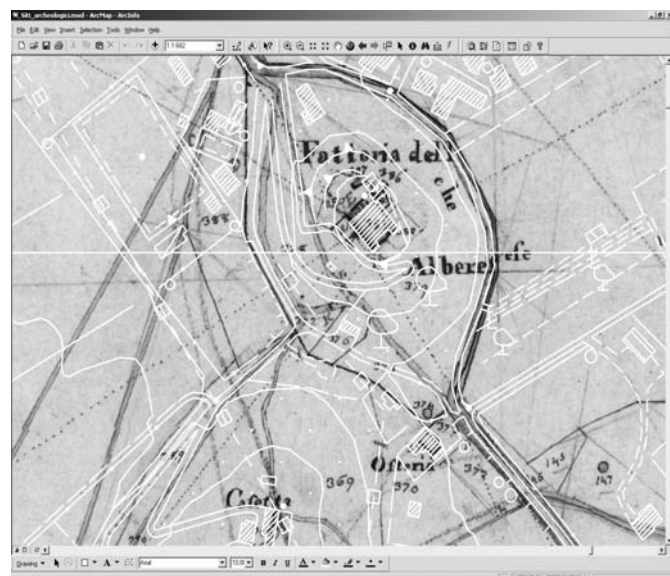


Fig. 4. Mosaic of of the Catasto Leopoldino maps of Grosseto: the accuracy of georeferencing is shown by the superimposed Technical Map of the Regione Toscana (in white, C.T.R. 1:10,000).

level of local accuracy, to within a few meters, can be obtained by simply translating the maps using a single ‘real’ control point. This accuracy is comparable to current maps of the same scale (Fig. 4).

4. Applications

The role and potential of historical cartography integrated in a GIS with different sources have already been outlined on other occasions (De Silva and Pizziolo 2003a; 2003b; 2004). Let us give a few examples, derived from ongoing research in various fields of application, in order to highlight the importance of accuracy in the phases of acquisition of data and georeferencing.

Historical cartography may contain information about archaeological remains or previous settings. By comparing the maps with more recent sources, within the same georeferenced framework, it is possible to check the reliability of data and the location of archaeological features. One example is the remains of the Aurelia Roman road reported in the Catasto Leopoldino maps. The presence and the correct position of the road is confirmed by clearly visible marks in the 1954 aerial photograph (Fig. 5).

Integration of different sources can be used for the diachronic analysis of landscape transformation processes. In the Grosseto area, the evolution of wetlands, marked by drainage and land reclamation works throughout the course of history, is highly significant for the understanding of historic settlement strategies.

Through the integration of different kinds of data, including those derived from historical cartography, it has in fact been possible to reconstruct the progressive shrinking of the Prile lake (the current day Padule di Castiglione) from the Etruscan age to the present day ((De Silva and Pizziolo 2003b).

A further application of integrating georeferenced sources related to different periods is represented by diachronic

analysis of coastline evolution. By comparing the historical cartography with recent aerial photographs, the coastline trend of the Maremma Regional Park area from 1820 to 1997 can be clearly traced (De Silva and Pizziolo 2003b; 2004).

The result of working with the GIS is that analysis and representation can no longer be considered as two separate procedures. The integration of data in a georeferenced framework enables new representations, greatly enhancing the potential of visual analysis. As an example of the interaction between the potential of representation and that of visual analysis, altimetric information has been added to a georeferenced mosaic of the historic cadastral maps. This highlights the relationship between roads of different periods and the relief of the land. The maps of the Alberese area show both Roman routes, the Aurelia, and those dating to the 1820’s. A new three-dimensional representation was obtained by draping the maps over a Digital Terrain Model which clearly outlines different road strategies. According to the differing importance of the roads and strategies, the path of the 19th century follows the foothill, whereas the Roman road prefers a more linear straightforward path along the plain (De Silva and Pizziolo 2003a).

5. Conclusions

The increasing interest in cultural heritage management and a greater general awareness of the importance of historical landscape settings and transformation processes in territorial planning, both encourage and spur historical geographers and archaeologists to find new solutions in the integration and sharing of data. Further improvements and new progress in geo-historical research are not only based on gathering of information, but more significantly on the integration and comparison of data within the same georeference framework. From this perspective, the need to acquire high quality data, which is both geometrically accurate and detailed, becomes crucial.

Each different research context and corpus of sources present particular problems which, within a more general theoretical framework, require specific solutions. This paper has attempted to point out some of the technical and methodological aspects concerning the processes of acquisition and the integration of historical cartography referring to a specific territory. The procedural problems and elements which have emerged from this case study attempt to exemplify a methodological approach which gives significant weight to the development and application of contextualized procedures.

Acknowledgements

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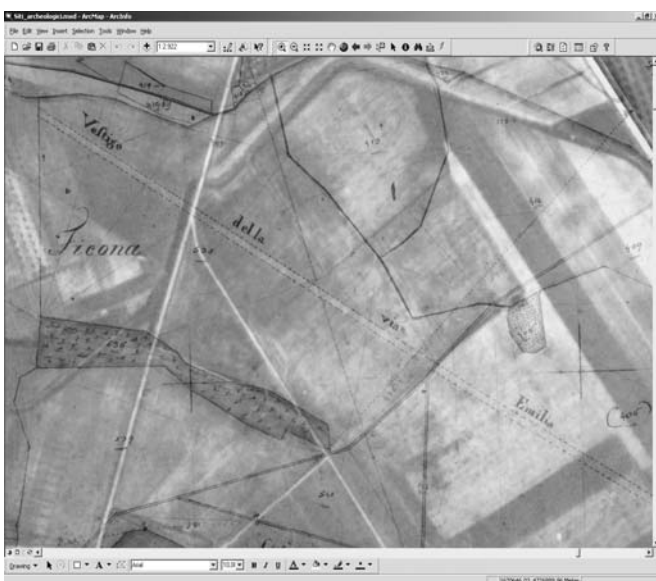


Fig. 5. The ruins of the Aurelia-Emilia Scauri Roman road recorded on one of the Catasto Leopoldino maps (transparent overlay) precisely match the marks on the 1954 aerial photograph.

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