

# GIS analysis of historical cadastral maps as a contribution in landscape archaeology

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## Introduction

The aim of this paper is to present some considerations on the role of historical cartography as a source of information in landscape archaeology studies and to explore the expansion of its potential through integration with other sources. This theoretical contribution is presented with the help of two case studies in which the Reverse Research methodological approach is undertaken within a GIS environment.

First, we would like to focus our attention on the nature of historical cartography, analysed in terms of an historical manuscript, a document, representing the archaeological map at the time of its creation (AZZARI *et alii* 2002). In fact, an ancient map represents the territorial settings of a landscape related to the historical context of its execution, providing a portrait of that historical landscape; moreover an historical map may contain traces and signs of previous settings still recognizable at that time. In some fortuitous instances, maps have provided a record of the position of ruins and/or archaeological evidence from which we have gleaned useful information about their existence, extent and position. Furthermore, it is necessary to interpret historical cartography, when viewed in this way, i.e. from the perspective of historical document and as a product of human invention, in terms of direct and indirect information that can be accessible to scholars today. It is especially important to systematically verify the data illustrated in a map in relation to its characteristics and position. In fact, maps signify, in a symbolic and iconographic way, the reality of the landscape of the past as perceived by the ancient cartographers who drew them. They are an intrinsic interpretation of the reality represented.

## Historical cartography and the Reverse Research approach

We can approach the study of historical maps by following two parallel and complementary directions of analysis: by interpreting the historical document from a semiotic and anthropological perspective, or by developing research from an historical and geographical point of view (Cuccoli et al. 1985). We are strongly convinced of the importance and efficacy of complementary studies but in this paper we are going to predominantly focus on the second type analysis.

Historical cartography offers a wide range of map typologies classifiable in terms of scale, thematic contents, techniques of representation and so on. In particular, a significant difference in cartographic production may be due to the adoption of various drawing practices such as a view in perspective, or a bird's-eye view, or other pictorial methods, which, from their complex results, can be very stimulating and exciting as regards the perception of the landscape and its representation, but which radically compromise, (when compared to planimetric illustrations, for example), the possibility of using ancient maps in a georeferenced environment (Azzari et al. 2002). For this reason, in the case of GIS analysis, it is important to subdivide historical cartography in terms of the geometrical characteristics essential to reliable GIS layer input: historical maps need to be transformed and warped in order to be adapted into a present-day geographical reference system. Consequently, the geometric quality of maps is a critical element to bear in mind. In this sense, planimetric maps, and in particular the cadastral maps of the 18<sup>th</sup> and 19<sup>th</sup> centuries, are optimal historical

sources to be used in landscape archaeology reconstructions performed with GIS. In fact some of these are excellent examples of geometric accuracy and, moreover, they offer detailed information and a wealth of thematic data. In order to carry on the research using historical cartography, it is important to assess and contextualise ancient maps and to enhance information in a diachronic and synchronic framework. It is thus important to integrate into the GIS several kinds of sources in order to obtain different thematic and temporal layers, taking advantage of the potential of thematic and spatial overlay. It thus is necessary to correlate the study of ancient maps with other information derived from recent maps and aerial photographs in order to investigate the changes in landscape during different historical phases. The methodological approach proposed in this paper is based on reverse historical geographical analysis. Research is developed starting from the analysis of today's landscape settings, going back in time to the interpretation of the settings of the past throughout the individuation of previous phases. In this way landscape settings are sliced in their historical stratification, proceeding in reverse through time, as in an archaeological excavation, from the most recent to the most ancient.

## Case studies

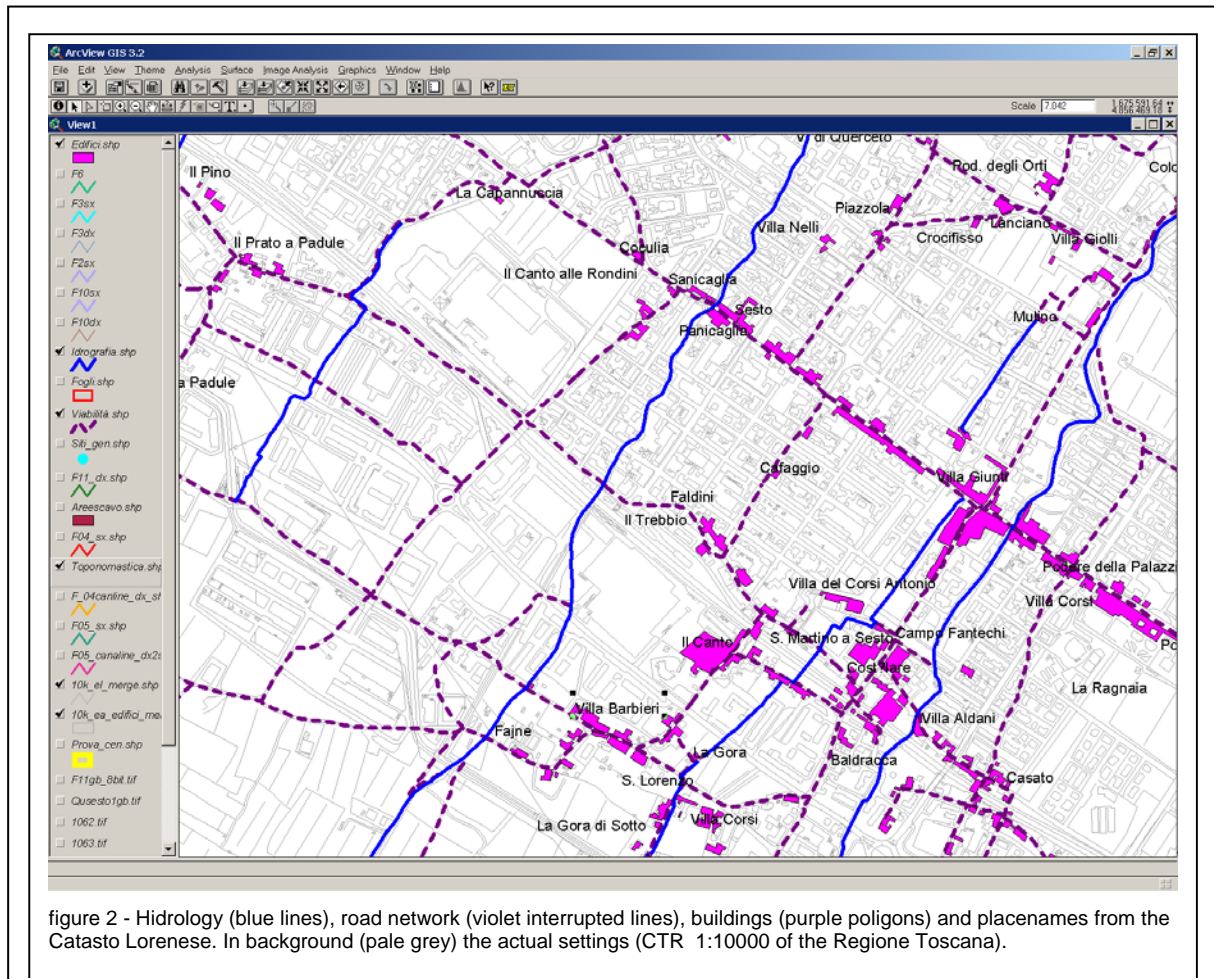
### 1 The sources

In this paper we are presenting some examples extracted from two work-in-progress case studies in which we have utilized the *catasto lorenese*, a geometric cadastre carried out for the whole territory of “Granducato di Toscana” between 1817 and 1835. The *catasto lorenese* is particularly rich in detailed

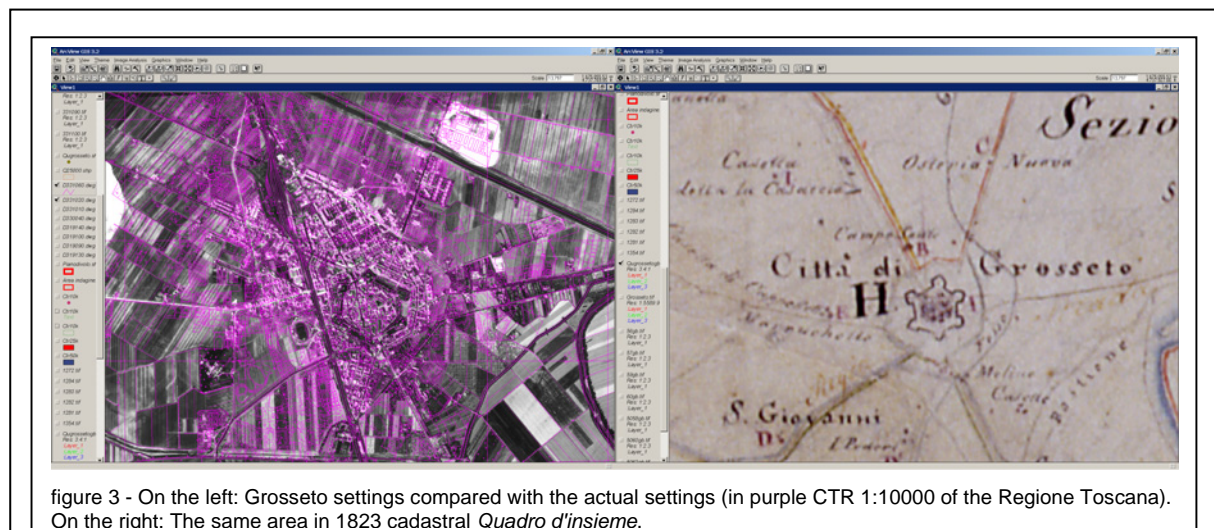


figure 1 - Catasto Lorenese, *Quadro d'Insieme della Comunità di Grosseto* (about 1823).

information documented in the form of maps, in the form of records in tables or inventories, and in a descriptive form as related texts. Maps are truly full of data and allow good and accurate georeferencing, while avoiding too much unwanted deformation of the features represented in the document. The subject matter particularly purposeful to our studies are the “Quadri d’insieme” (fig. 1), i.e. the general framework topographic maps varying in scale from 1:25,000 to 1:80,000, and the “Fogli”, detailed maps generally at a scale of 1:2,500 or 1:5,000.



The historical maps have been acquired into the system and the main features (such as hydrology, settlements, road networks and place names) have been digitised in thematic layers (fig. 2). Besides the



acquisition of these ancient maps into the GIS and the subsequent analysis of the historical information which they offer, it is important to contextualise them within the dynamic transformation of the landscape (fig. 3). For this reason it seems fundamental to integrate the research with other sources to input into the GIS. In this case the comparison with aerial photographs produces very exciting results.

In this paper we begin by analysing two particular photo series that are portraits of two different phases of 20<sup>th</sup> century landscapes in Tuscany: the most recent one, which refers to 1997, at a nominal scale of 1:10,000, provides information for contemporary landscape settings. In terms of the previous settings, that is to say how the landscape appeared before the extensive transformation in the post sixties period, we have chosen the VOLO GAI, shot in Tuscany in 1954 at an approximate scale of 1:33,000. The quantitative and qualitative comparisons between these sources performed throughout GIS allow us to highlight the transformation trends occurring from the beginning of the 19<sup>th</sup> century until today. The analysis was developed focusing on two zones: the Sesto Fiorentino area and the Grosseto plain (fig. 4).

#### Case study 1: Sesto Fiorentino

Sesto Fiorentino is located on the northwest side of Florence's surroundings, partially occupying the Florentine plain and partially extending to the gentle slope of Mount Morello. Currently, the Municipality of Sesto is a satellite urban centre of the large metropolitan area of Florence and, in the last twenty years, its territory has been subjected to intense urbanisation, involving an increase in communication infrastructures. It was during this urban expansion that a large amount of archaeological evidence was uncovered, and the ongoing systematic rescue excavations have exposed several periods of occupation from Neolithic to medieval times (Martini et al. 1993). Recent development has strongly affected the landscape, which appears significantly transformed when compared with the 1954 settings (fig. 5). The

comparative analysis between aerial photos (1997 - 1954) reveals general changes in land use, which have deeply overwritten the previous land texture. Dramatic changes occurred not only on the level of urban expansion. In fact even where the agricultural zone has been preserved, changes have taken place in terms of the type of cultivation, and we can observe a shifting from the present single crop system to the traditional mixed agricultural system of the past. Proceeding thus in a reverse direction in this matter, we have assessed what was the situation at the beginning of the 19<sup>th</sup> century. The cadastral maps<sup>1</sup> testify to a general continuity in landscape settings between the beginning of the 19th century and the first half of the 20th century. In order to better perform a field system comparison, we have elaborated the historical maps by means of the Erdas Imagine 8.5 software. Using a series of filter applications we have highlighted the orientation presented by field patterns and subsequently vectorised them in a semiautomatic way. This elaboration allows us to easily compare different phases. The comparison between the cadastral maps and

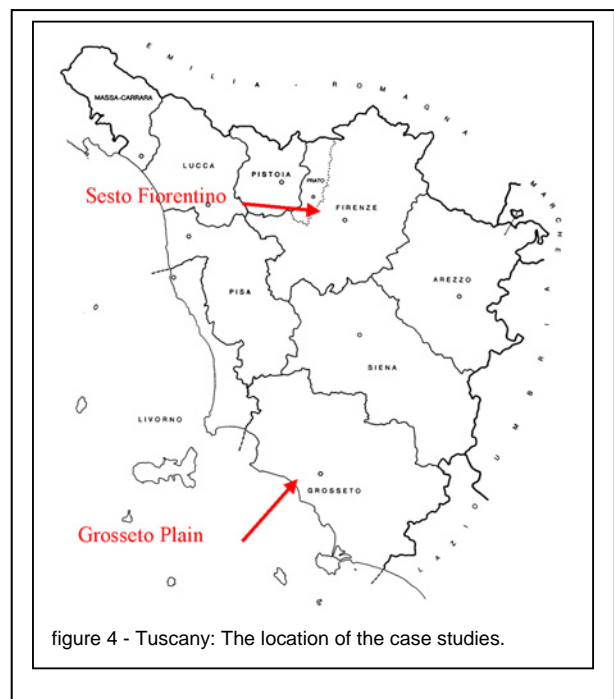
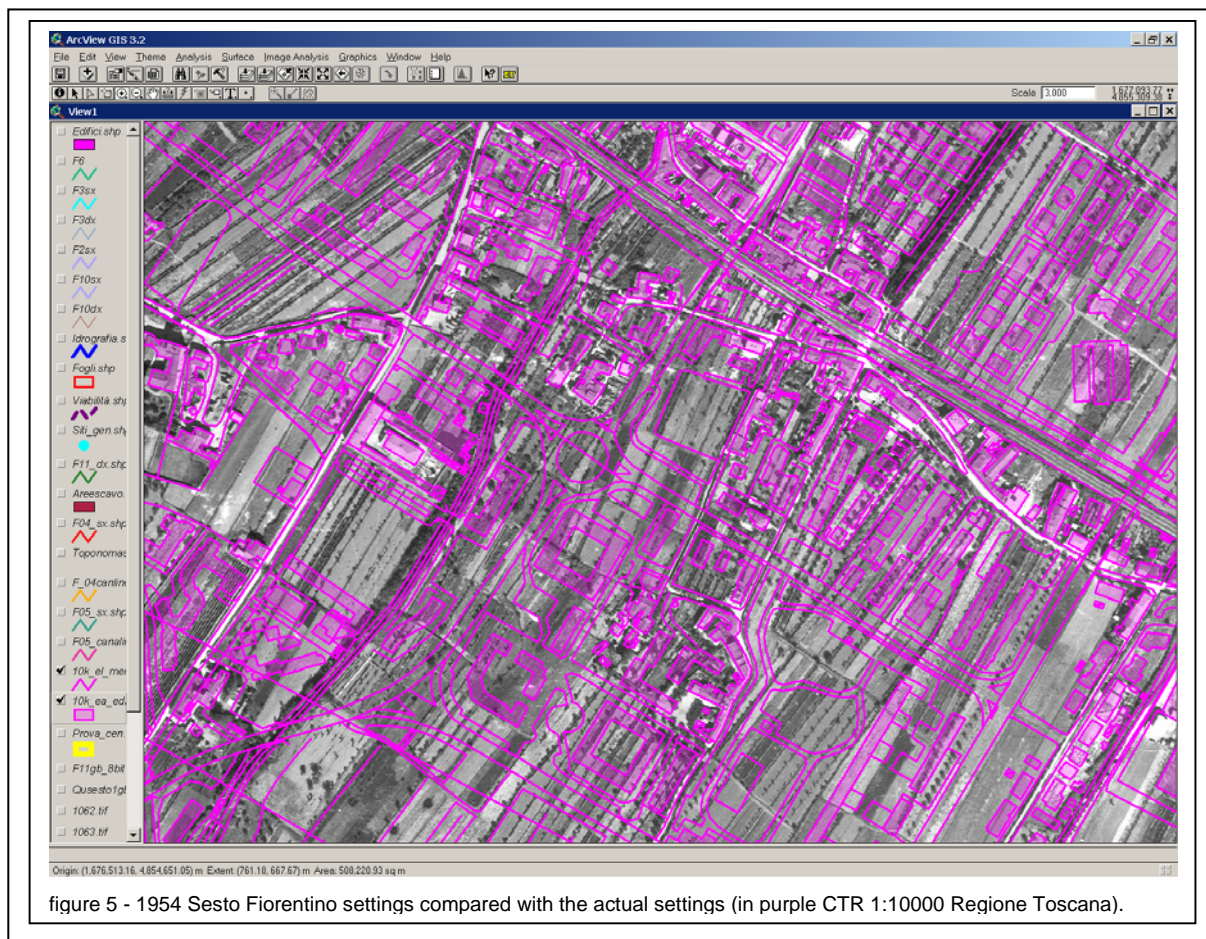


figure 4 - Tuscany: The location of the case studies.



the 1954 aerial photos shows that the general settings, in the rural plain areas, remain almost the same, as can be seen by observing the field patterns (fig. 6). Road and water networks show the same trend (fig. 7). Moreover the analysis of the 19<sup>th</sup> century landscape, as it is represented in the maps, offers evidence of the territorial organisation in more ancient periods, recording the continuity and changes that have occurred in the territory. In order to distinguish traces and signs of previous territorial settings we have focused our attention on the Roman period, which had a huge impact on the landscape and continued through time, the permanence of the centuriation network, to represent a very significant historical and landscape marker. Moving forward from this perspective we have built up a grid with a 355 m side module that in the Sesto Fiorentino Plain corresponds to the module of Roman centuriation and subsequently we have “anchored” and oriented that grid, based on the archaeological field evidence attested to in literature (Cresci et al. 1999). In this way we have built up a layer reproducing the highly probable centuriation grid (Peterson et al. 1995). We have consequently overlaid the grid onto the thematic layer extracted from the 19<sup>th</sup> century cadastral maps (fig.8). The comparison between these frameworks confirms the continuity in field system and territorial settings. In fact the position or orientation of a lot of segments of the centuriation grid matches with the road and water network of the 19<sup>th</sup> century, providing evidence of the strong markers imposed on the landscape in the Roman period. Moreover, the strength of the Roman pattern is observable in the landscape subdivisions executed by the cadastral cartographers. In fact the borders between the different maps, the “fogli”, follow partially the centuriation *limites* (fig. 9). The strength of the Roman landscape organisation is also exemplified by the continuity in orientation in the field pattern both in the northeast-southwest direction or the northwest-southeast direction.

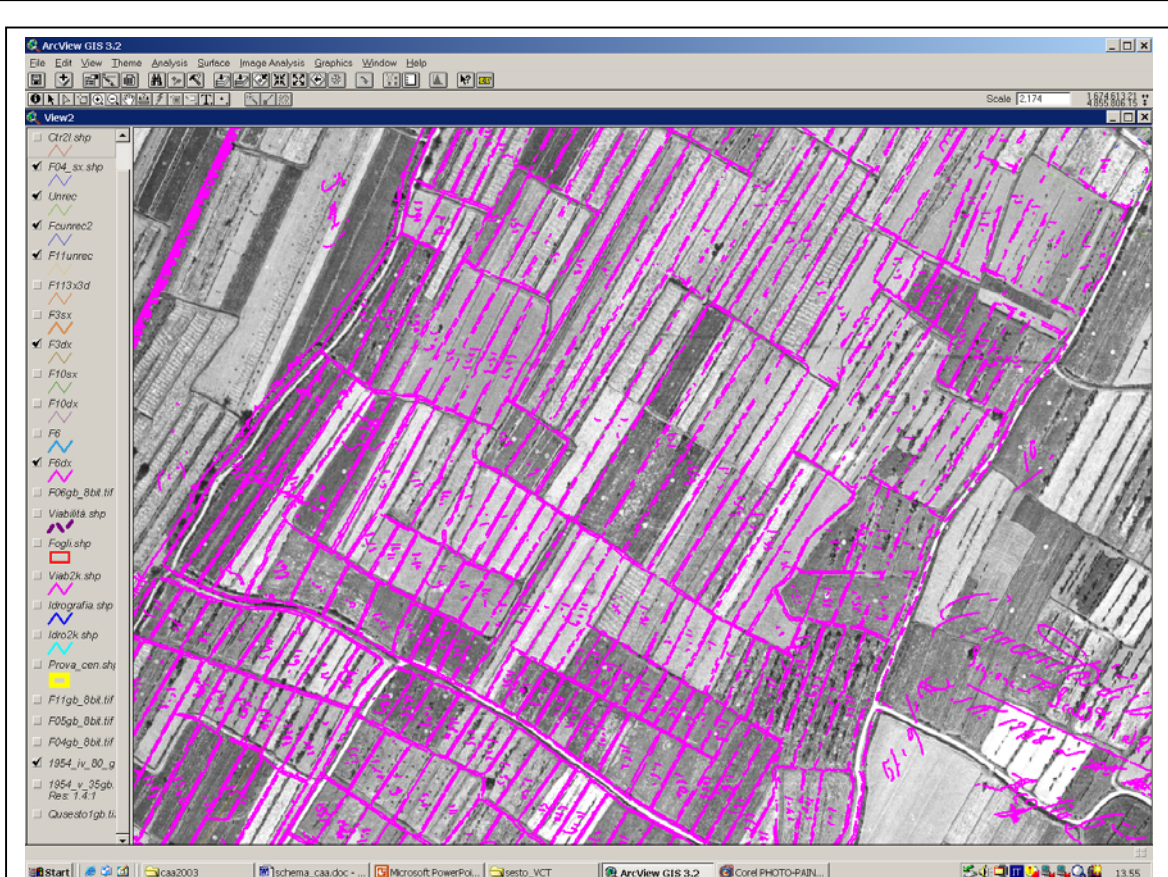


figure 6 - 1954 Sesto Fiorentino settings compared with the 19<sup>th</sup> century settings (in purple the layer derived by 1823 cadastral map)

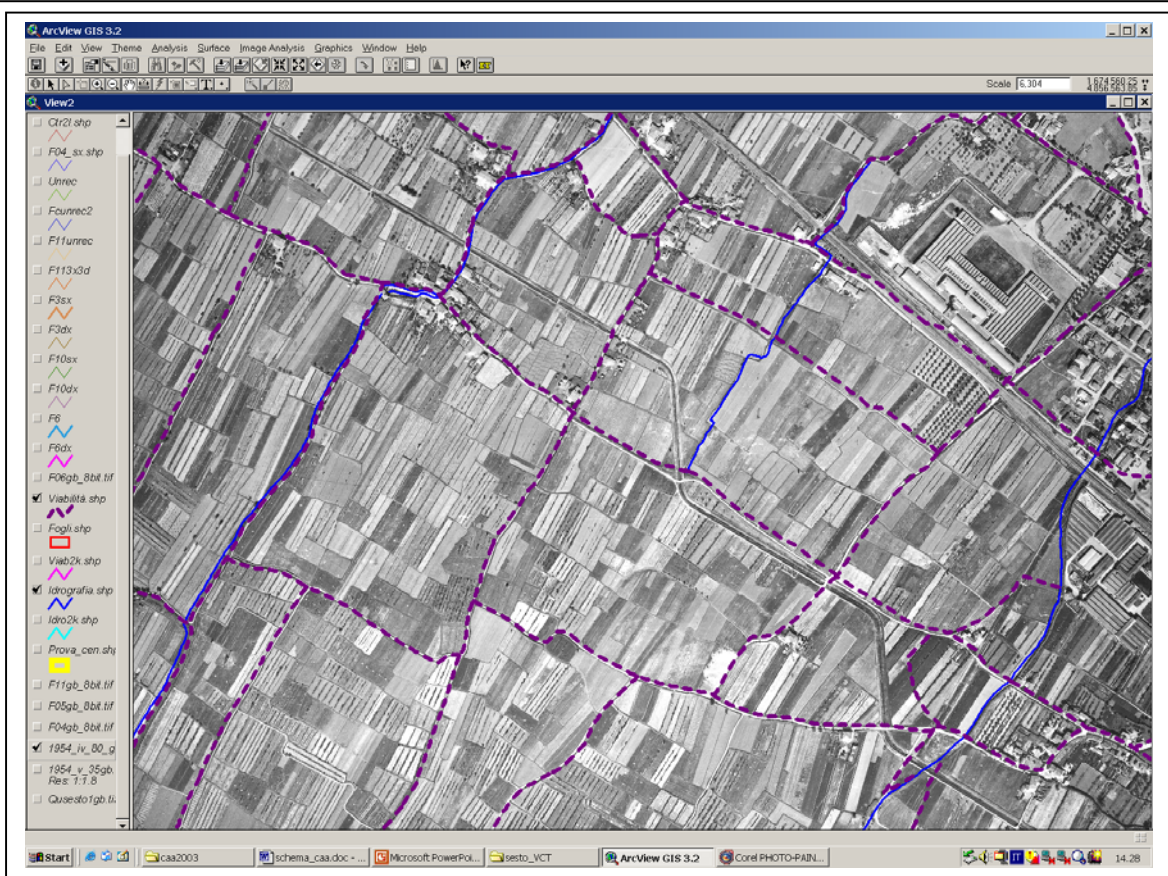


figure 7 - 1954 Sesto Fiorentino settings compared with the 19<sup>th</sup> century settings (Hidrology blue line, road violet line).

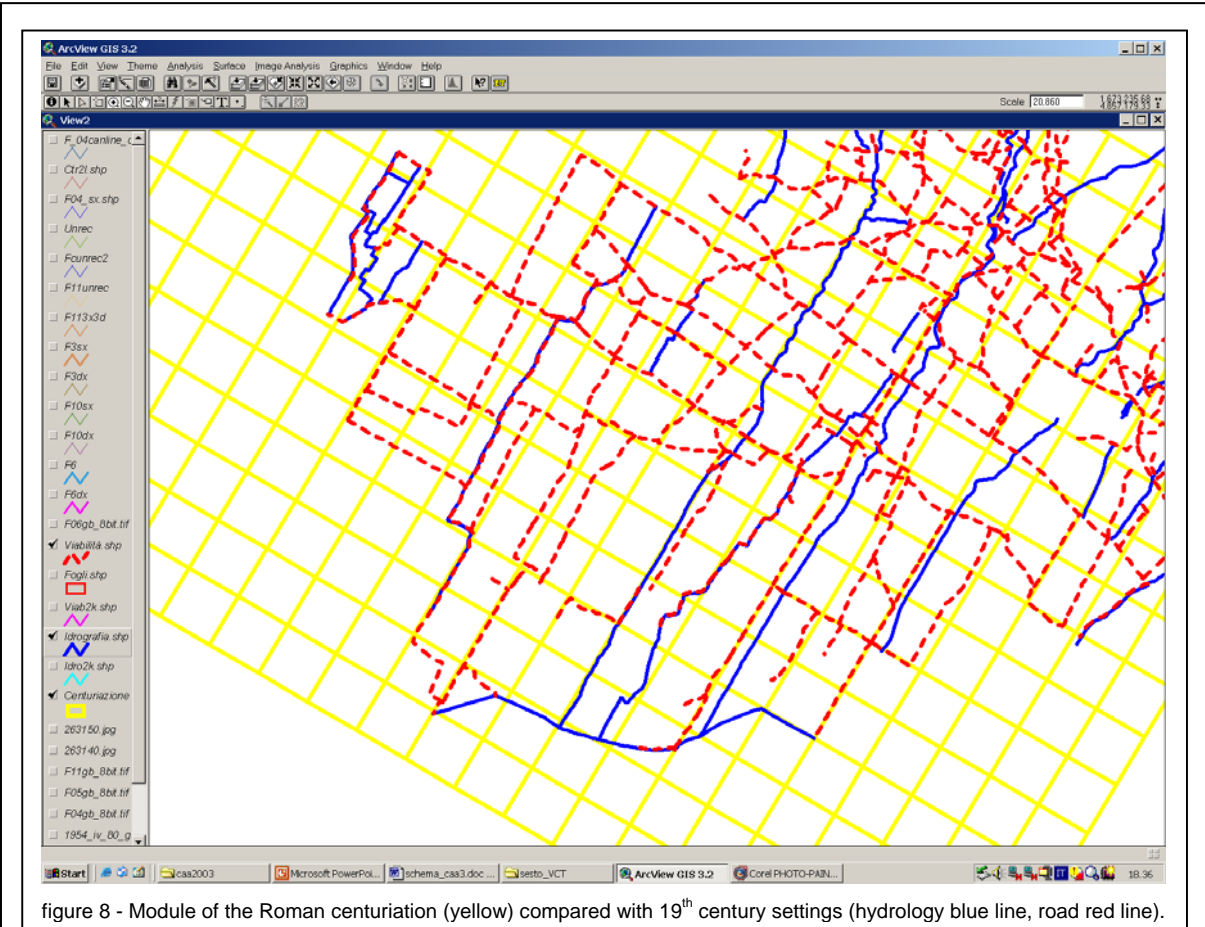


figure 8 - Module of the Roman centuriation (yellow) compared with 19<sup>th</sup> century settings (hydrology blue line, road red line).

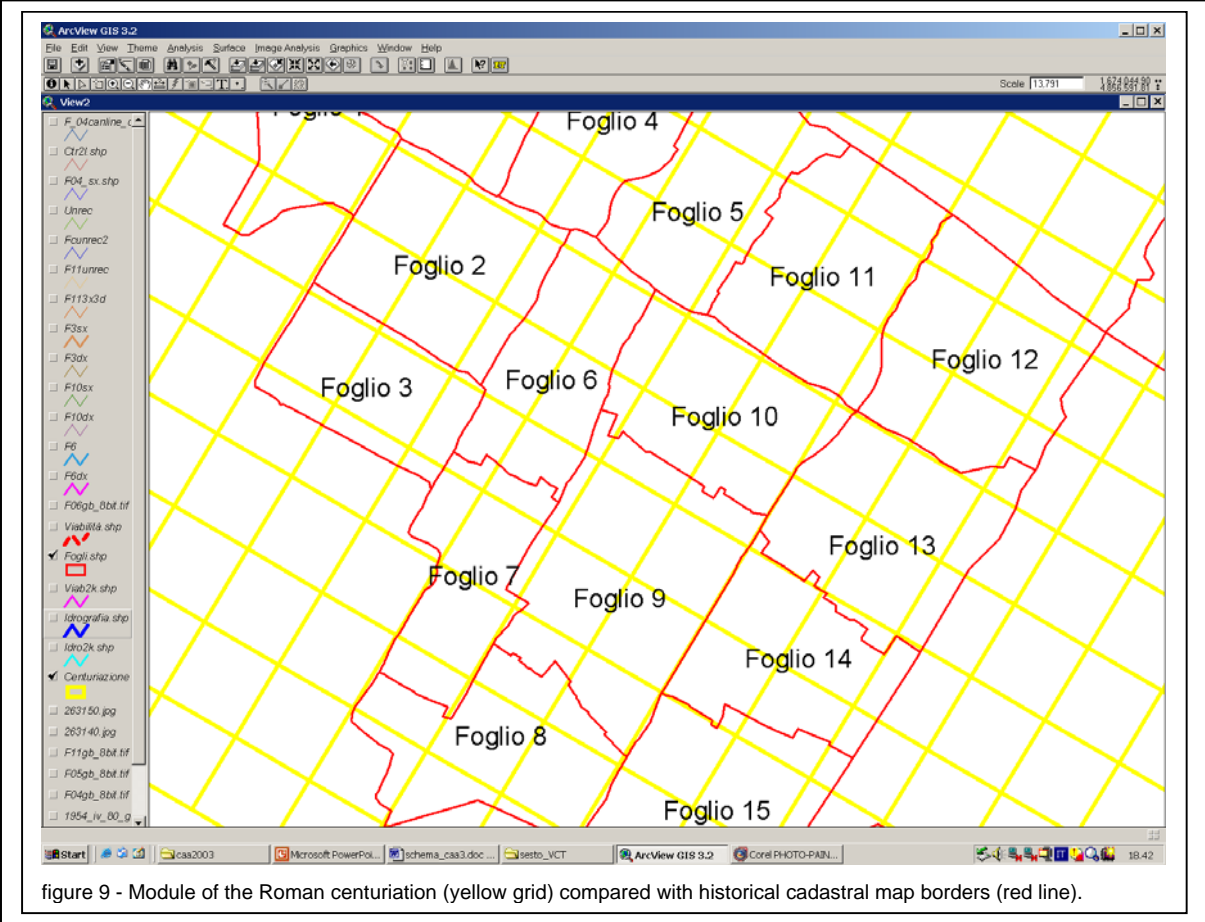
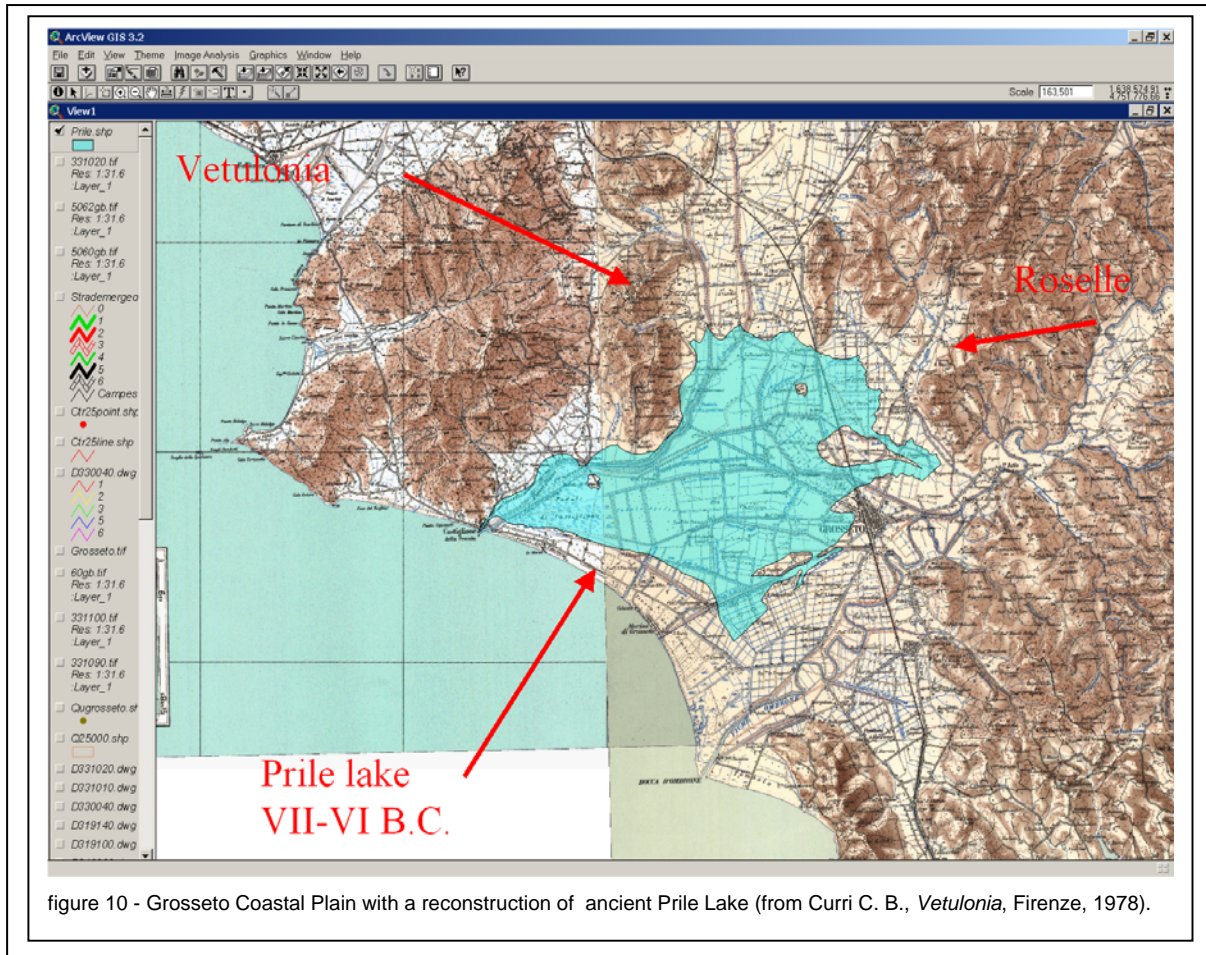


figure 9 - Module of the Roman centuriation (yellow grid) compared with historical cadastral map borders (red line).

### 3 Case study 2: Grosseto plain

The Grosseto coastal plain is located in southern Tuscany. A large part of this wetland area was occupied during the Etruscan and Roman periods by Lake Prile. In the northern part of the area the ancient cities of Vetulonia and Roselle were facing the lake from an elevated position (fig. 10). After the Roman period the lake progressively turned into a swamp. From Medici times through the last century, the area underwent a series of important reclamation and drainage activities.

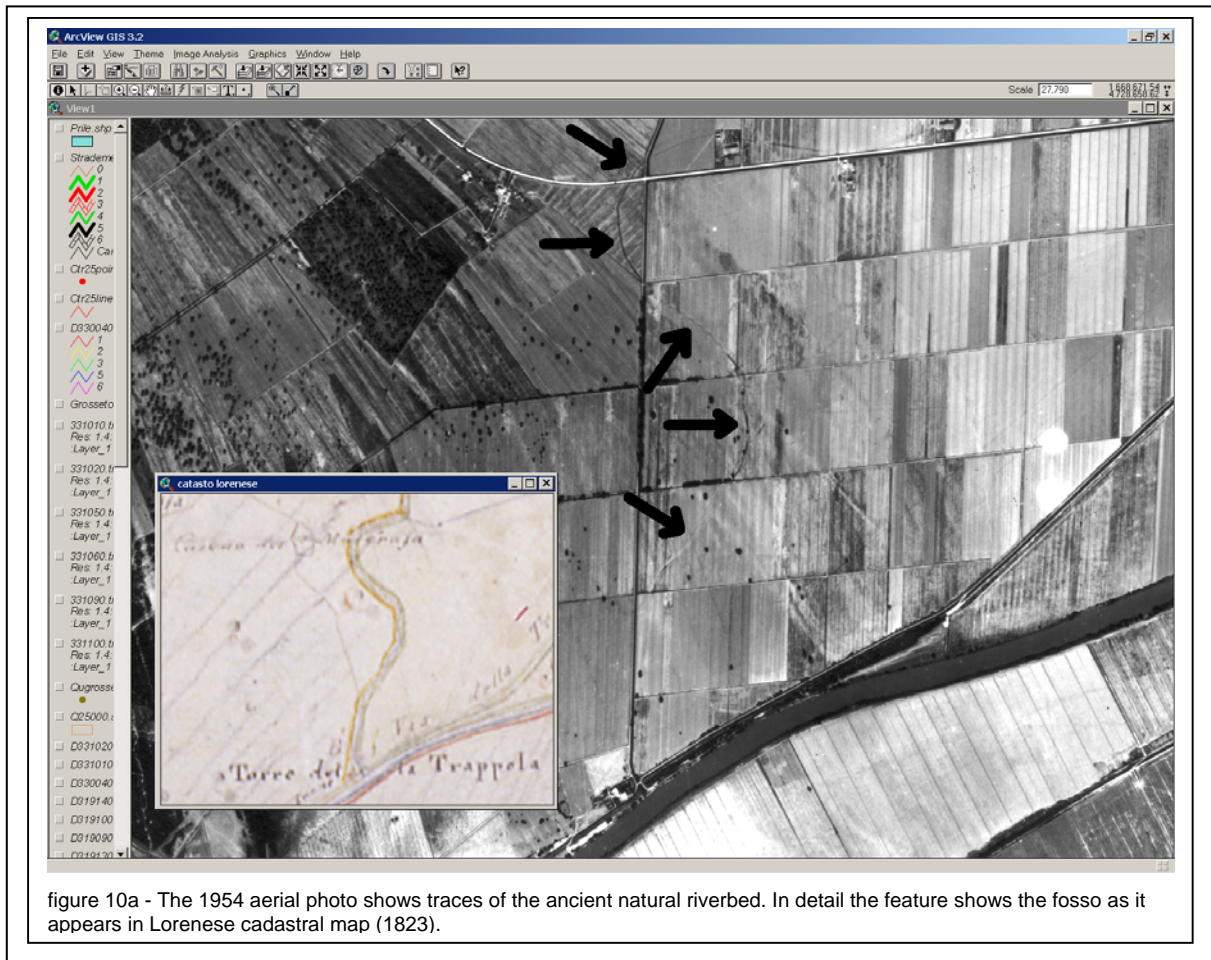


Throughout the case studies presented we would like to underline the potential of the Reverse Research analytical approach undertaken in conjunction with the help of other sources. In particular, by means of the integrated analysis of aerial photos (especially from the past) and historical cartography, we can obtain a great deal of precise and varied information, both explicit and implicit. This methodology allows us to highlight the occurrence of interesting features from a landscape archaeology perspective. In addition, this type of analysis sometimes provides chronological information and, above all, it offers – contrary to other analysis techniques - the exact localisation of these features. The Reverse Research analysis on the Grosseto plain, presented in this paper focuses on landscape transformation with regard to hydrology, coastline and traces of ancient roads.

First we will examine the Fosso Razzo, a small right side tributary of the Ombrone River in the vicinity of its mouth. Today the small watercourse is constricted into a regular channel and the observation of the recent aerial photo doesn't allow us to individuate any trace of its natural course. By contrast, in the 1954 aerial photo, we can see, in the vicinity of the artificial channel, clear signs probably denoting the ancient natural riverbed. The overlay with historical cadastral maps<sup>2</sup> confirms the interpretation of the anomalies seen in the



aerial photo of 1954 (fig. 10a). In fact, in the 19th century map we can observe a sinuous watercourse, which exactly match the traces previously individuated, giving evidence that in 1823 the *fosso* was not yet rectified.



The Reverse Research analysis technique may also be applied to the study of coastal shoreline change. In fact, the well-executed geometrical characteristics of the Lorenese cadastre permit us to perform an accurate analysis of the extension of the coastline in the proximity of the Ombrone River mouth. The overlay of aerial photos and historical cadastral maps of different periods permits us to follow the steps in erosion of the coastline, which has retreated about 1km since 1823 (fig. 11).

Furthermore the integration of different sources may help in understanding archaeological evidence. Particularly in the case of the Grosseto plain, the historical cadastral maps testify to the presence of remains of the Aurelia Roman road. The interrupted line symbol, adopted by historical cartographers to portray the remains of the ancient Via Aurelia, and the text line on the map "traccia dell'antica via Aurelia" indicates that the road was not in use in the early 19<sup>th</sup> century. The Lorenese cadastre also indicates the presence of ruins of a bridge ("rovine del ponte del diavolo") located on the edge of the Ombrone River's final bend, which the ancient maps called the "volta ai marmi" ("river bend of marbles"), a clear reference to the presence of a roman bridge. In the 1997 aerial photos, the traces of the Roman road have almost disappeared. By contrast, in the 1954 aerial photos, these traces are still present and very sharp. It is exciting to realize that by comparing the aerial photos with historical cartography we are now able to interpret these photo anomalies as the Aurelia Roman road (fig. 12).

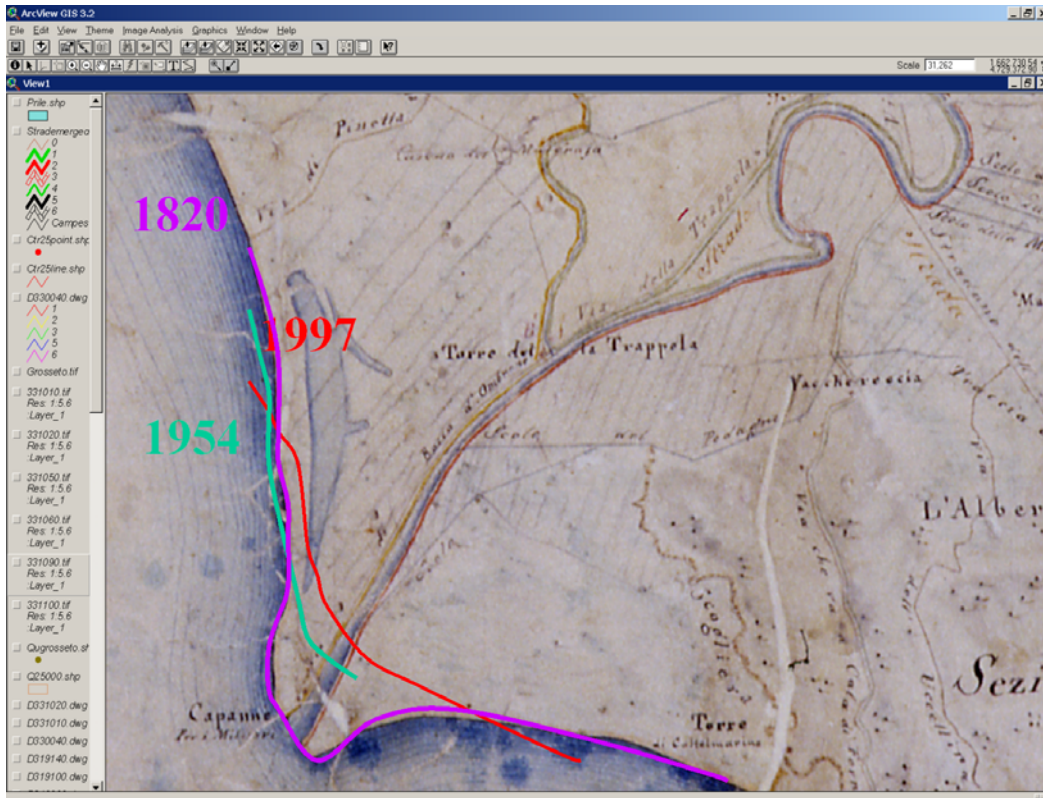


figure 11 - The overlay of aerial photos and historical cadastral map shows the erosion of the coastline in the proximity of the River Ombrone mouth (lines represent the coastline: violet 1820, green 1954, red 1997)

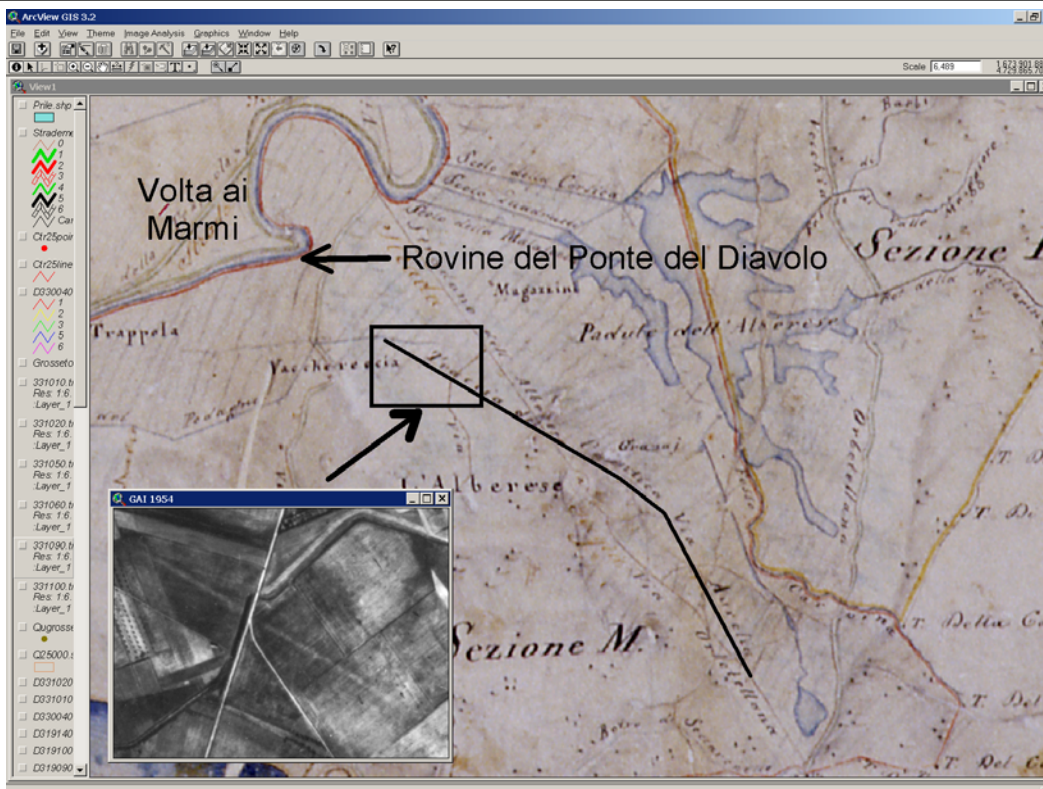
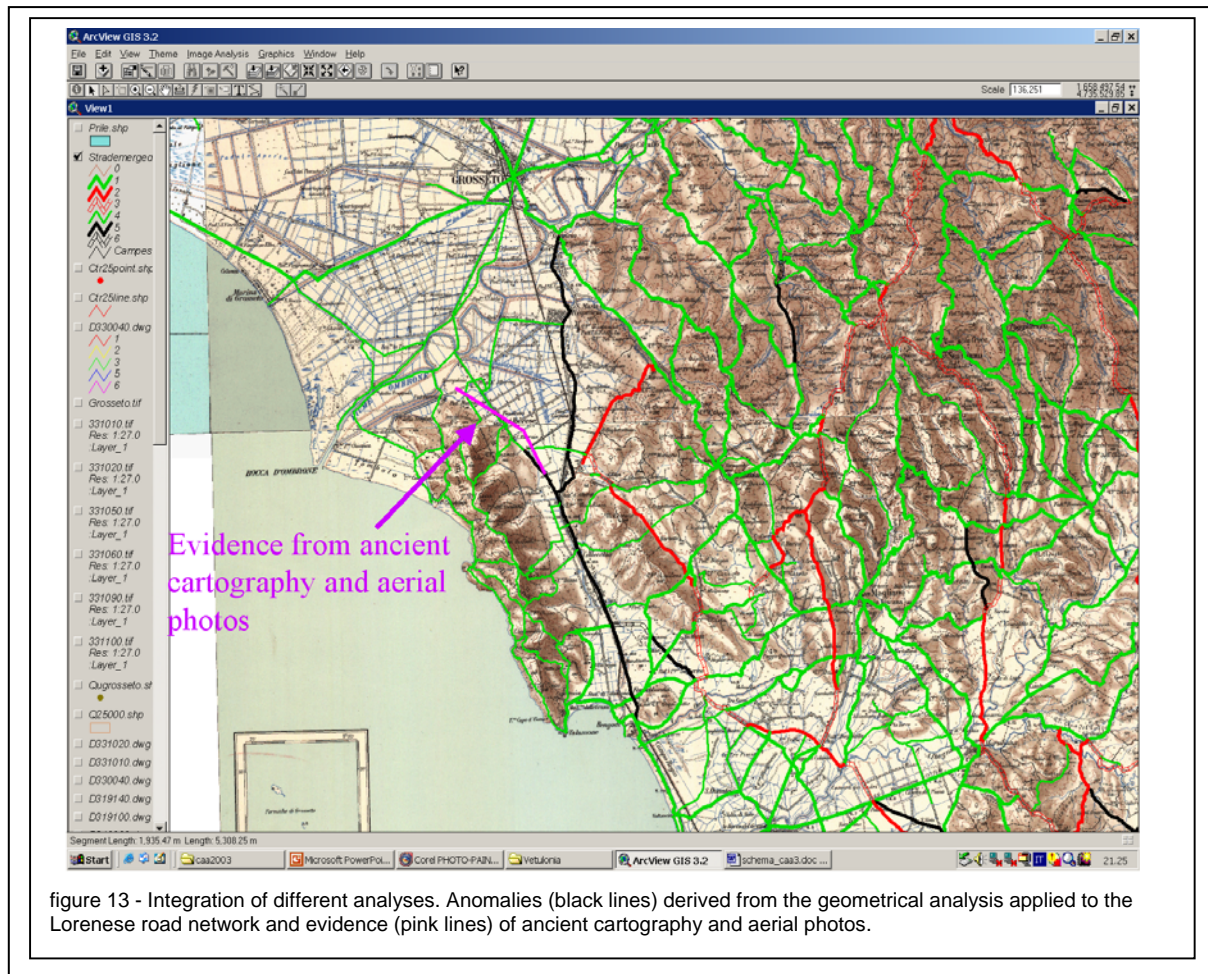


figure 12 - "Trace of the ancient Aurelia" roman road in the Lorenesse cadastre (black line). In detail the road trace in the aerial photo of 1954.

The effectiveness of data integration has been widely demonstrated (Vermeulen et al. 2001) and it becomes especially relevant when we are dealing with landscape features with complex stratification. Also pertinent to this mode of research is the integration of data derived from different kinds of analysis. In particular, the results obtained in the last example have been correlated to data gathered from a geometrical analysis applied to the Lorenese road network. This analysis (Azzari et al. 2000) highlighted anomalies in network connectivity, perhaps bearing witness to road segments belonging to a higher level, or having an older origin than the local inter-village road network. If we compare (figure 13) these anomalies with the results previously presented, we can recognize some of these segments as a part of the Roman ways, thus establishing a more comprehensive view of the Roman road network in this area.



## Conclusions

The case studies presented above are focused on the advantages of data integration involved in our Reverse Research method of analysis. Following this approach, Landscape has to be considered not in a synchronic way, but as the dynamic result of an historical sedimentation process, in which different events have left traces one on top of the other, becoming a complex whole. The Reverse Research method of analysis together with the integration of different sources allows us to display separate layers of historical sedimentation. From this vantage point, the use of georeferenced historical cartography and its integration with data derived from other sources leads us to explore new complementary interpretations and opens stimulating research possibilities in landscape archaeology studies.

## Note

This work has been carried out in full collaboration by the authors. In particular paragraph 3.2 has to be attributed to Giovanna Pizziolo and paragraph 3.3 has to be attributed to Michele De Silva.

Aerial photographs reproduced in this paper derive from photographic archive of Istituto Geografico Militare, (Autorizzazione n. 5763, in data 1.07.03).

Maps used as background in fig 10 and fig.13 derived from “tipi dell’Istituto Geografico Militare” (Autorizzazione N. 5769 in data 10.07.03).

The images of ancient cartography of Lorenese Cadastral map related to Grosseto Plain (ASG Antico Catasto Toscano- Comunità di Grosseto - Quadro d’Unione) have the following authorization: *Archivio di Stato di Grosseto, n° prot. 2572/X.1-1 del 22/09/2003.*

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<sup>1</sup> These maps of the “Catasto Lorenese” are placed in the Archivio di Stato di Firenze. We are really grateful to Dr. Francesco Martelli for his kind collaboration and precious suggestions.

<sup>2</sup> These maps of the “Catasto Lorenese” are placed in the Archivio di Stato di Grosseto. We are really grateful to the Director of the Archive Dr. Maddalena Corti for her kind collaboration.