

# Landscape Archaeology in the Sesto Fiorentino Area: the Contribution of Aerial Photographs to the Study of Archaeological Contexts as Part of an Integrated Approach.

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**Abstract.** The on-going recovery excavations in the territory of Sesto Fiorentino (Florence, Italy) reveal that the plain area has been extensively settled ever since prehistoric times. This paper represents our attempt to read the complex palimpsest of this archaeological landscape within a GIS environment, all the while bearing in mind the context in which the populating process occurred. Different sources of information have been integrated into the GIS; in particular aerial photographs and ancient cartography have been used to reconstruct the different phases of landscape transformations in this ancient wetland area. Through the study of infrared aerial photographs, we strive to illustrate their contribution in investigating the relationship between environmental and archaeological perspectives. In particular this paper focuses on the research potential provided by IR aerial photographs and their accuracy in providing information on ancient wetland areas.

## 1. Introduction

Sesto Fiorentino is a town located on the northwestern side of Florence at the foothills of Mount Morello. In the last twenty years the urban expansion of Sesto Fiorentino, now stretching across the Florentine plain, has enabled the archaeologists of the Universities of Siena and Florence to discover a substantial body of evidence, identifying a wide temporal and spatial range of archaeological and palaeo-environmental contexts (Martini and Sarti 1993, Martini et alii 1999).

The analysis of this data shows that since prehistoric times the area was constantly inhabited and with particular intensity during the III-II millennium when Calcolithic and Bell Baker people settled recurrently in the plain area.

Geomorphological studies (Condrea and Ercoli 1973, Capecchi et alii 1975) suggested that the inner basin of the Florentine plain was a wetland area during the prehistoric

period and that creeks, marshes and bogs dominated the landscape. From this perspective, it has become increasingly challenging to explore the various circumstances of these past successions of settlement by taking advantage of the potential offered by GIS and other analytical tools. This paper, a work-in-progress, describes the integration of different kinds of data into a unique system, focusing on the contextual reading of the archaeological landscape. Our research examines the essential contribution of infrared aerial photo analysis and in particular its accuracy in distilling information on ancient wetland areas. These photographs shot in the Sesto Fiorentino plain have generously been made available by CAVET (Consorzio Alta Velocità Emilia Toscana) and FIAT-ENGINEERING.

## 2. The Research Context: Sources and Methodologies

The research is based on the integration of different sources with the aim of correlating the multiple elements, which may have played a role in the constitution of the archaeological landscape. The methodology adopted for the project is the Reverse Research Approach (De Silva and Pizzolo 2004). The research begins with the analysis of today's landscape settings and then moves backwards through time individuating each of the previous phases. In this way each landscape period is visualized, identified, and "removed" in relation to historical position, proceeding in reverse through time from the most recent to the most ancient. Therefore the analysis of cartographical sources is a fundamental step in the individuation of the different historical phases that the area has passed through confirming either continuity or changes in the territorial settings of Sesto Fiorentino. The cartographical sources used for this project are extensive and take into

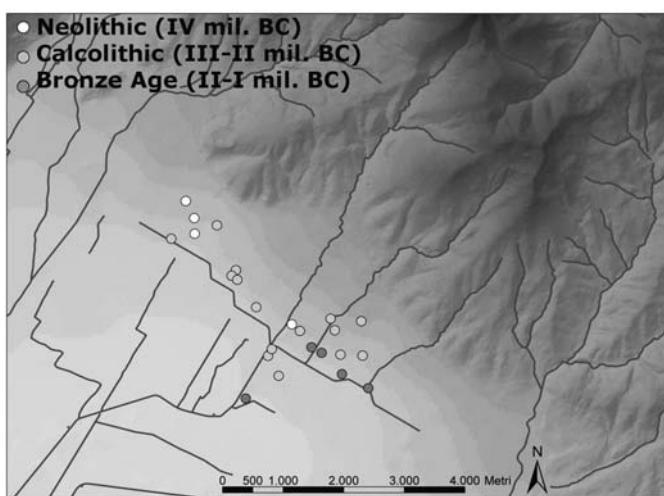


Fig. 1. Prehistoric site distribution in Sesto Fiorentino context.

account actual topographical and technical maps (from a scale of 1:100.000 to a scale of 1:2.000) as well as historical cartography dating back from the end of nineteenth century to the sixteenth century. The contribution of ancient maps is particularly significant from several points of view. Once historical documents have been interpreted and verified, they can provide a considerable amount of meaningful information regarding the previous landscapes and the way in which they were perceived by ancient cartographers (De Silva and Pizziolo, in press).

The input of ancient maps into the GIS involves several acquisition procedures and image transformations (Azzari et alii 2002, De Silva and Pizziolo 2003, De Silva and Pizziolo 2004) leading to a geo-referencing of cartographical drawings. Among the ancient maps examined for the project is the key historical cadastre, entitled the "Catasto Leopoldino" (1817–1835), made for the Grand Dukedom of Tuscany. The cadastral maps have been geo-referenced, and information on hydrography, road networks, settlements, buildings, place names, and field extensions has been inputted into different vector layers. This data constitutes a rich source of information, as regards territorial settings of the nineteenth century, but it also substantially identifies evidence of previous periods (De Silva and Pizziolo 2004). One such identification has been the confirmation of Roman Centuriation organization imposed upon the Sesto Fiorentino area during the first century BC. (Bacci and Giachetti 1995).

Other essential sources are historical and present-day aerial photographs. The comparison between photographs shot in 1954 and the ones shot in 1997 highlights details in changes occurring during these last decades. An interesting piece of information deduced through this comparison regards land use transformation (De Silva and Pizziolo 2004). Historical aerial photos also supply the necessary background to elaborate a well-informed geomorphological interpretation of the plain area. The individuation of alluvial fans and paleo-rivers is clearly readable on those photographs portraying the Sesto territory as it appeared before the radical transformation typified by urban expansion. Moreover the input into the GIS of the 1954 aerial photos has proved invaluable for the individuation and mapping of ancient wetland areas.

In order to reconstruct the ancient wetland settings of the Sesto Plain, we have also used Infra Red aerial photographs to better interpret wetness values from the analysis of infrared sensitivities. Correlating, comparing, and evaluating a combination of data sources is a fundamental step to assessing the accuracy of interpretation and individuating also key features and significant or promising areas of study. The results may be even better understood and enhanced when satellite images will be available for this project.

### **3. Landscape Archaeology at Sesto Fiorentino**

According to various authors (Capocchi et al. 1975, Martini et al. 1999), the Sesto Fiorentino territory was, during prehistoric times, a wetland area most probably characterised by the presence of streams and small water swamps. The evolution

of the lacustrine basin of Florence has been previously studied in larger picture incorporating Florence, Prato, and Pistoia. The absence of detailed data for the subset of Sesto Fiorentino precludes an exhaustive and meticulous palaeoenvironmental reconstruction of our study area. However it is worth noting that the general impression of the evolution of a wetland landscape may be borne out by the scarce permeability of the geological structure, a situation in effect especially after the filling in of the basin. The presence of palaeo-riverbeds, alluvial fans, and colluvium previously identified by means of photo-interpretation (Conedera and Ercoli 1973) has been mapped into the GIS and transformed into vector layers. We then created an "historical" DEM of the study area, ensuring that the additions of the last century to the highs and lows of the landscape were eliminated. Then the geomorphological thematic layers and the information extracted from the historical cadastral maps were draped onto the elevation model. The model has been used to provide all the features of the third dimension. It is worth noticing that the nineteenth century field systems may show anomalies or irregularities in shapes and once draped onto the DEM, they may confirm or suggest palaeo-hydrological interpretations. The comparison with the 1954 aerial photographs draped onto the model elicits additional recognition of these implications.

Moreover if we observe prehistoric site distribution draped onto the DEM we can appreciate all manner of differences pertaining to chronological periods. Neolithic sites are mostly located on gentle micro-reliefs and generally positioned closer to the foothills of Mount Morello rather than located in the middle of the plain area. In contrast, as regards the later periods, i.e. the Chalcolithic, the Bell Baker Culture, and the Bronze Age, we notice that sites gradually progressed towards the central part of the plain. This could well be related to contraction of the wetland shorelines and swamps. Within this framework, it becomes increasingly relevant to analyse the site distribution in terms of proximity to hypothetical shorelines or rivers and to define the micro relief of the plain. Furthermore as far as concerns settlement strategy, the archaeological excavation revealed that during the Chalcolithic Period people settled extremely close to the palaeo-river or inside the bed itself. The exploitation of the area involved anthropically modified palaeo beds in order to build a living floor or some sort of settling structure.

Thus we may deduce that in order to devise a more comprehensive assessment of the Landscape Archaeology of the Sesto Plain, it is essential to recognize the palaeohydrology aspect. What sources can we access in order to investigate this wetland environment?

As we have seen, the historical aerial photos and cadastral maps provide interesting information on field patterns, which can generally be used to individuate hydrological anomalies. Moreover they contain, in themselves, accurate details about water networks that we can use to compare with other particulars on the region, having either a direct or indirect bearing on the archaeological data. The opportunity is also there to compare these historic layers with the present day situation. We have found the use of colour infrared aerial photography to be an excellent resource to exploit.

#### 4. The Infrared Aerial Photographs

The CAVET and FIATENGINEERING, two companies in the process of developing a new high-speed rail transit system in the territory of Sesto Fiorentino, have made available to the University of Siena several false colour infrared sensitive aerial photographs. These photographs, at an approximate scale of 1:6000, were taken by CAVET as a study aid in the planning of the railway track, which is to traverse the southern part of the recently expanded urban community. In order to ascertain the geographical characteristics of the area they used the KODAK AEROCHROME III Infrared Film 1443, which is a medium resolution, fine grain, infrared-sensitive and false-colour reversal film. FIAT ENGINEERING provided us with both the transparency and print copies of the photographs.

False-colour films can be used to emphasize the differences between objects that are visually quite similar. Colours are reproduced falsely on KODAK AEROCHROME Infrared Films. In the transparency photographs the resulting colours after exposure and processing are as follows: infrared radiation appears as Red, Green reproduces as Blue, Red reproduces as Green, and Blue in the original subject has not been recorded because of the yellow filter (minus blue) always used over the camera lens, and is therefore rendered as Black. Numerous other colours will be formed, depending on the proportions of green, red, and infrared reflected or transmitted by the original subject (Eastman Kodak Company 2003). Due to the characteristics of the Kodak film, we were able to scan the transparencies and prints of the aerial photographs at 1200 dpi in a RGB mode. The RGB acquisition allowed us to separate the specifics related to reflected and transmitted colours of the Sesto Fiorentino territory on three levels. These images were then imported into the software Erdas 8.5 in order to geo-reference them with the Italian grid system based on the Roma 40 coordinates, and to perform an analysis of their informative content.

Even though it is not possible to analyze the absolute values (DN) of the individual pixels as in a satellite imaging system, however, in performing an RGB scanning analysis, and when

comparing and contrasting the different sensibility characteristics of the film in relation to the Red, Green, or Blue bands, and finally when detecting the infrared component in the photo, it is possible to realize our goal of analysing the humidity, wetness, and saturation characteristics of the land in question, i.e. the Sesto Fiorentino region. Therefore we can consider the use of infrared aerial photography as an invaluable tool in our on-going archaeological exploration of this specific area.

#### 5. The Contribution of False Colour IR Photographs

From an analysis of the medium scale aerial photographs we can deduce more than just routine facts. If we focus our attention on an examination of moisture levels and on an elaboration of the band combinations within Erdas 8.5, then we can enhance the already established features by further adding to the geomorphological and especially to the hydrogeological framework already inputted into the GIS. Several elaborations have been performed but the most effective one has been the calculation of the NDVI (Normalized Difference Vegetation Index). It is standard practice to obtain the index by determining the ratio between the infrared minus the red reflectance and the infrared plus the red reflectance, but in our case the index is obtained by determining the ratio between Red (corresponding to the infrared) minus Green (corresponding to the red) and Red (corresponding to the infrared) plus Green (corresponding to the red) RGB bands. As we all know the Normalized Difference Vegetation Index provides information on vegetation status but it may also indicate the wetness quality of the soil because of the mutual correlation between good conditions of vegetation with wetness intensity. Thus we decided to compute the index in our study area because we were certain it could provide us with useful results especially when compared with other acquired data recorded in the GIS. Obviously it is necessary to take into consideration that the urban environment produces an enormous quantity of "noise", which, in turn, interacts in diverse ways with soil characteristics. In addition, the presence of pipelines and other underground features, all by-products of recent human activity occurring in the plain, can lead to a confusion of readings and thus mistaken interpretations. Nonetheless some remarkable facts probably related to prehistoric settlement distribution have come to light.

##### The Lastruccia Case Study

We have chosen to present as a case study the archaeological context of Lastruccia, situated just south of the Sesto Fiorentino centre. In this area, new installations and buildings, as a result of urban expansion, have uncovered a multi-period prehistoric site where evidence of a Bell Baker settlement is located in a paleo riverbed. The settlement strategy related to this choice of habitat is still to be clarified. However the suggestion that a drainage base, created by the gravel of a paleo riverbed in a wetland area, was motivation for the



Fig. 2. A detail of IR aerial photo focuses on the Lastruccia site (black areas).



**Fig. 3.** The NDVI elaboration highlights the small palaeo-river (pale grey) in the proximity of Lastruccia site (black areas).

establishment of a community is quite compelling. We may surmise that during the third millennium water streams were considered an important economic resource of the landscape and, by the same token, the bed of a temporary or palaeo river constituted an advantageous location to exploit, at minimal human cost and energy, for the purpose of settlement in a wetland area. With this in mind, we have considered it our utmost objective to gather all minutiae available to us with which to construct a comprehensive palaeo environmental framework. The analysis of the aerial photographs as well as the geomorphological features shows that large palaeo rivers crossed the Lastruccia area, thus confirming the data brought to light by archaeological excavations (Martini et alii 1999). Our study of infrared aerial photos and of the particulars revealed by our application of the NDVI further corroborates the presence of vegetation intensity corresponding to the palaeo river zones (on those parts of land not actually covered by recent buildings), and it also shows, within an area corresponding to open fields the existence of a small very sinuous feature with an extremely high concentration of vegetation.

Because of the homogeneity of land use, a variation in the index may be attributed to different soil characteristics, quite probably to wetness intensity. The distinctiveness of this feature is also made evident by means of a HIS visualization of the RGB bands. This newly discernible feature in the landscape has never been identified in previous studies and is presently under investigation. If further analysis determines that this entity under observation conforms to the exact nature of a palaeo-river, then we have to understand if the small “paleo stream” could be a tributary of the general hydrological setting or whether it constitutes an element that predates, is contemporary to, or postdates the general palaeohydrological system as it has been perceived in earlier studies (Conedera and Ercoli 1973).

Whatever the exact nature of the sinuous palaeo-river, it is still important to integrate it within the geographical framework. By changing the zoom level, and by examining the Sesto Fiorentino territory within the landscape of the Florence-Prato-Pistoia plain in its entirety, it has come to our attention that the direction and orientation of the hypothetical



**Fig. 4.** The palaeo-rivers (sinuous black lines) and the feature (inside the black rectangle) individuated through NDVI, within the territory.

palaeo-river is consistent with the general North eastern and South western hydrographical flow and it matches as well the direction of the other main hydro system from the highest point down towards the centre of the plain.

We know it to be true that any kind of aerial photo interpretation serves to enhance and refine palaeo-environmental reconstruction and in particular, wetland area definition (Ghedini et alii 2002). Moreover in the Sesto Fiorentino plain, which has been dramatically altered in the recent past, it is worth comparing, contrasting, referencing, and consulting each and every one of the resources at our disposal. If, as it happens, an intimation or a suggestion of a palaeo-river comes to light in historic cadastral maps, in the guise of field system anomalies, then it would become especially appropriate for us to analyse the spatial relationship between the anomalies and the infrared values. The discovery of either continuity or changes, when performing this comparison, would make it possible for us to corroborate the received data or to designate if a shift in time has arisen between the occurrences of these phenomena

## 6. Conclusion

The goal of this paper has been to demonstrate the various elements in a work-in-progress designed to integrate every information source available to us into a GIS and thus establish a meaningful all-inclusive context with which to execute our investigation of the archaeological landscape. With the results obtained through the use of Erdas 8.5 analysis system, we have been able to examine the contribution of infrared aerial photographs in the Sesto Fiorentino plain and add them to a broad-spectrum interpretation of the geographical arrangement in its totality. The archaeological data gathered in the case study of Lastruccia has given us the incentive to further elaborate a contextual reconstruction in order to confirm any possible hypotheses and/or propose new questions about settlement strategies. The research potential of infrared aerial photographs may be exploited in future along with an exploration of pertinent indexes within the field of landscape archaeology interpretation. In the case of Sesto

Fiorentino, the NDVI has proved a useful tool for highlighting wetness intensity and revealing other interesting features. A further interpretation of soil characteristics could be extrapolated by means of satellite images when available. We expect that many new and exciting concerns and possibilities will come to our attention in the future and we will earmark them for evaluation and comparison with the results and assessments we have already gleaned through our scrutiny of the aerial photos of the region.

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