1. Project and Methodology

This contribution presents an analytic study of a sample area, chosen for its geomorphological characteristics and cultural complexity. The study area, located in Southern Apulia (the so-called Tavoliere di Lecce) consists of a sedimentary plain mostly formed by limestone deposits creating a gently folded, eastward-dipping monocline, bordered by the sand coastline of the Adriatic sea to the East (fig. 1).

In recent years we have been implementing a GIS concerning the present administrative territory of Lecce (Territorium Lupiaensis in Roman times) as part of the wider Carta Archeologica della Puglia meridionale Project (Guaitoli, 2001). We executed:
1) intensive field archaeological surveys,
2) the analysis of multi-temporal vertical aerial photographs (Sammarco, 2011),
3) a long-term programme of archaeological aerial-survey and
4) the excavation of the pier dated back to Emperor Adrian’s age (Sammarco & Marchi, 2012) recently integrated with GPR survey and 3D reconstructions.

In this GIS we have processed data derived by field surveys, laboratory research and integrated studies: about 150 topographic units (sites and off-sites) have been identified (fig 1, top), dated back from the Bronze Age to the fifteenth century. The processual methodology has been adopted in surveying and processing data but without deterministic approaches. Flexible standards have been applied in quantitative and qualitative analyses of ceramics assemblages. A very accurate study of sherds allowed us to identify diagnostic items for defining site typology, chronology and, more generally, the related changes in land use.

We choose for its representative value the backland of San Cataldo harbour as a sample area. Here rural settlement slightly increased between first century BC and first century AD, testifying to the Romanisation process in this district. Analysis of data derived from survey activities revealed that the full functionality of the ancient harbour required the inland presence of a productive and receptive territory, with the distribution of rural settlements closely connected with the coast and the road system.

As well, the research project focused on the Roman concrete structure still preserved at San Cataldo (40°23'22" North 18°18'25" East) along the shoreline and in shallow water.

The Roman building was already known beginning in the sixteenth century AD as part of an ancient harbour. Artistic and very interesting drawings were realised during the planning of a new breakwater in the 1800s (Sammarco & Marchi, 2012). In addition, archival documents furnish detailed descriptions of the ancient remnants, indicating its original overall length of ~150 m, whereas the present surveyed length is ~60 m. The reduction in size was the result of the systematic demolition of the monument in 1901 to obtain material to use in the construction of the new breakwater, built behind the ancient structure and still partially preserved.
The pier (fig. 2, bottom) shows a compact structure and consists of two outer walls ~15 m distant from each other. The curtains are made by large squared limestone blocks and filled with hydraulic concrete made with a strong mortar mixed with a local stone aggregate; this aggregate varies in size and composition and is unevenly distributed within the concrete. Certainly, the use of such large blocks was induced by the opportunity to quarry lithic building materials from the surrounding areas. Lithic blocks are used, as well, to realise the mooring rings projecting from the inside face of the breakwater.

Information on the age of the structure are substantially derived from historical sources (Paus. 6.19.9), which refer to the construction of the pier during Hadrian’s Age (first half of the second century AD). The building technique of the San Cataldo pier can be observed in several other structures of the Mediterranean Basin [Brandon
et al, 2014; Marriner & Morhange, 2007) referred to a long stretch of time included the end of the Ellenism and the beginning of Roman Age.

In order to identify lithological and micropalaeontological features of lithotypes used in the Roman monument, small samples from limestone blocks and from inner concrete have been collected and examined in thin sections (fig. 2, top left). In particular microfossils assemblages provide a valid proof for determining the geological provenance of lithic materials, identified in a wide outcropping area at Acaja, located a few kilometers inland from the ancient harbour (Sammarco et al, in press).

The main aim of the GPR prospection (fig. 2, top right) was to identify the remains of the ancient structure possibly buried under the modern square, following the descriptions provided by many authors in many reports written in the last two centuries. Compared analysis of GPR information and data derived from archival sources was very useful for planning out the second archaeological excavation campaign just concluded.
2. Aerial survey activity

Evidence from aerial sources can help to reveal the formation processes of archaeological contexts over long periods of time, combining airphoto-interpretation of historical vertical photographs with more recent images acquired from UAV platforms or from traditional light aircraft.

Recent changes in Italian legislation regarding aerial photography (Ceraudo, 2013; Mussone, Palmer & Campana, 2013) allowed, beginning in 2006, the development of a specific long-term archaeological air-survey programme in Salento performed through low elevation flights for shooting oblique images (Sammarco, 2008; 2011). Despite the strong distortion of oblique images, the spatial information can be corrected using algorithms developed in specific software and can thus be mapped and integrated into archaeological GIS datasets. In addition, we are continuing to study historical aerial photographs, particularly aerial photographs taken by the Institute of Military Survey from the 1930s to the 1950s; in this field our work consists of mapping anomalies recorded in the last 20 years of aerial activity and on repeated analysis of the images using digital image processing techniques.

A specific long-term archaeological air-survey programme was performed with low elevation flights able to shoot oblique images (fig. 3). This allowed us to test specific procedures for the organisation and the management of data-flights (new archives of oblique photos, GPS track-logs from the flights, GIS data entry) combining traditional methods of field survey and air-photo analysis of historical vertical photographs (fig. 4, top). In ideal conditions this technique offers, in South Apulia, an extraordinary contribution to for searching new sites and for the continuous monitoring of local cultural heritage.

In particular, we explored the archaeology of the relationship between Lecce, a pre-Roman settlement which later became a Roman colony, and its port at San Cataldo, on the Adriatic Sea some 12 kilometres away, which managed its overseas commerce activities in the past. The landscape between the two sites is rapidly changing because of aggressive agricultural development, the urban expansion of Lecce and tourist development along the coast. Thus, the knowledge acquired by the project can be used to assess the changes of past use and to establish the correct ways to exploit this sector of the coastline, making sure that the local cultural and archaeological heritage is safeguarded.

About 80 hours of flight time covered the study area, collecting more than 400 oblique photographs. Aerial survey flights were carried out with ideal soil and sea conditions and visibility, documenting well-known settlements and several new sites visible with crop-marks and damp-marks. Inland, the studied settings include urban settlements and monuments of significant archaeological and architectural interest.

3. Field Survey and GIS Data Management

Field activities are aimed at the systematic investigation of the sample area and at verifying remotely sensed evidence. An assiduous program of archaeological field walking in the area of the ancient Roman Lupiae helped to identify the traces of small rural settlements as well as a number of roads, both within the urban layout and outside the city wall.

During field surveys, traditional field-walking methods were combined with digital topographic methods. Each topographic unit (fig. 5) was surveyed and mapped using GPS; archaeological information has been organised into a specific database, with the aim of exploiting the spatial analysis capabilities of the GIS. Our work consists of the elaboration of a powerful cartographical database, including the spatial location of sites, individual graves or necropolis, ancient roads and their attributed data. In this way it is possible to create and display thematic maps in order to trace a reconstruction of the social organisation of ancient landscapes. In particular, during the survey, measurement of the areas of archaeological presence were made via the GPS receiver, which
allows the immediate transfer of the geographic information within the GIS.

During field survey, about 150 topographic units (sites and off-sites) were identified dating mainly from the Bronze Age to the Middle Ages. In the study area, the Bronze Age, the Iron Age and the Messapian period are not significantly documented. Two furnaces recovered in the nearby Masseria Rammanno (Valchera & Zampolini Faustini, 1997) date to the Late Republican Age (second-first centuries BC). They were found crucially close to the port of San Cataldo where the amphorae (so called “brindisine”; figure 5, right bottom nn. 4 and 5) were sent to be exported elsewhere in the Roman Empire.

During the Roman Age the rural landscape in the Salento Peninsula was apparently characterised by a small number of towns, a plethora of small scattered settlements and a lesser number of medium-sized agglomerations for which, in certain cases we might, perhaps, use the term vicus (De Mitri, 2010). Apart from a few areas that were of difficult agricultural exploitation, as in the Le Cesine coastal marshes and some woodlands, the landscape in the study area seems to have been quite abundantly populated. Rural settlement (largely farms) slightly increased between the first century BC and the first
century AD, most of them documenting a continuity of occupation till the Late Antiquity.

In Byzantine times a number of human settlements of Late Antique date seem to have been populated continuously; as well, new sites could have been founded in that time, probably favoured by external factors (presence of water, soil fertility, visibility, communication networks, the existence of the seaport, etc.). Even if it is not yet possible to assign a precise chronology to these sites, the pottery suggests occupation between the eighth and tenth centuries. Their presence may indicate a certain agricultural vitality of the land to the East of Lecce, notwithstanding the scarce data available from the town itself (Arthur, 2012). Example of a Byzantine foundation is the new site recovered during archaeological field survey nearby Masseria Erchie Grande (fig. 5). Also recovered is the settlement nearby Masseria Gennarano, related to the already known necropolis (Valchera & Zampolini, 1997). Ongoing, in the last centuries of Medieval Age, the number of settlement decreases; despite this, the postmedieval period registered a repopulation of the rural landscape. In the study area, the principal road system, but even a significant part of the second-

Fig. 4. Digital mapping of archaeological record: [top] in grey the areas no more visible (urbanism), in red the archaeological units, in pink a large group of linear features related to the road system derived from interpretation of historical aerial photographs (bottom).
ary road network (country tracks) extant in Roman times, must have remained more or less intact. Not only will some routes have been used to link settlements and to provide access to fields and other resource areas (quarries, harbour, etc.) but the very existence of a communication network, perhaps to a great measure, will also have conditioned the positioning of new settlements.

4. Conclusion

The reported research represents an excellent opportunity for testing the potential of GIS systems in combination with conventional methodologies for landscape analysis, archaeological excavations and the application of new technologies.

This integrated system of knowledge aims at two main goals: sophisticated elaboration of complex datasets, and practical possibilities for preservation of the archaeological heritage, by providing efficient tools to the management of the territory and its cultural components.

Aerial survey clearly represents a powerful basis for the integration and better understanding of data from a variety of investigative techniques, including ground-based survey, geophysical prospection and specific GIS applications. The results obtained in both urban and large-scale rural contexts have confirmed the huge potential of data derived from multi-temporal aerial photographs in the identification and mapping of archaeological sites for heritage management and protection as well as for enhancing public interest and understanding.

Finally, we would like to remark that the progressive integration of survey techniques (aerial, field and GPR survey) directly responds to the need to answer specific historical and archaeolog-
ical questions or to face specific methodological problems. Our approach has allowed us to define a variety of research strategies for a better understanding of the past.

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