Archeologia e Calcolatori
28.2, 2017, 253-266

OPEN ARCHITECTURE RDBMS AND GIS AS TOOLS FOR ANALYSING THE ETRUSCAN PRESENCE IN THE PO PLAIN: TOWARDS A MODEL OF THE URBAN/NON URBAN LANDSCAPE

1. Introduction

The Po Plain was affected by the presence of Etruscan groups from the 9th century BC on. To the N of the Apennines, the area with the greatest number of finds is the plain around Bologna – not at that time a truly urban centre – which was dotted with small settlements gravitating towards the city. A notable change in the Etruscan presence on the Plain is seen from the middle of the 6th century BC, when the nature of the population of the area changes radically (de Marinis 2007; Sassatelli 2008). Where in previous centuries occupation consisted of small Villanovan communities we now see a notable increase in population. The new settlement model was not based exclusively on the exploitation of the agricultural potential of the Plain, which, however, remained a fundamental resource, but seems rather to have been oriented towards a reorganisation of travel routes, focused on strengthening or creating safe organised routes for commerce (Sassatelli, Macellari 2009, 119). From this time on, we see a new model of population aggregation, which seems to follow these routes and their important traffic flows and is distinguished by the birth of urban forms. The demographic and settlement pattern became much more structured, with urban centres, secondary centres and farms, in contrast to the preceding pattern of sparse, small settlements. The current research sprang from this situation[1], aiming to readdress the so-called "Po Plain issue" in the whole area N of the Apennine crossings.

2. The project: the GIS, the database and the quality of the archaeological record

The GIS presented here had the initial aim of providing a complete digital catalogue of the 6th to 4th century BC Etruscan sites known on the Po Plain[2]. A second benefit of such a cartographic and information-rich GIS database is the possibility of using it to consider possible interpretations of the archaeological record and its relationship to the evolution of the landscape, considering the

[1] In this paper, I will present several results from my PhD research conducted at the Università degli Studi di Milano: Quirino 2015.

[2] The catalogue covers the period to 2015 but I would argue that new discoveries would not substantively alter the results of the analyses.

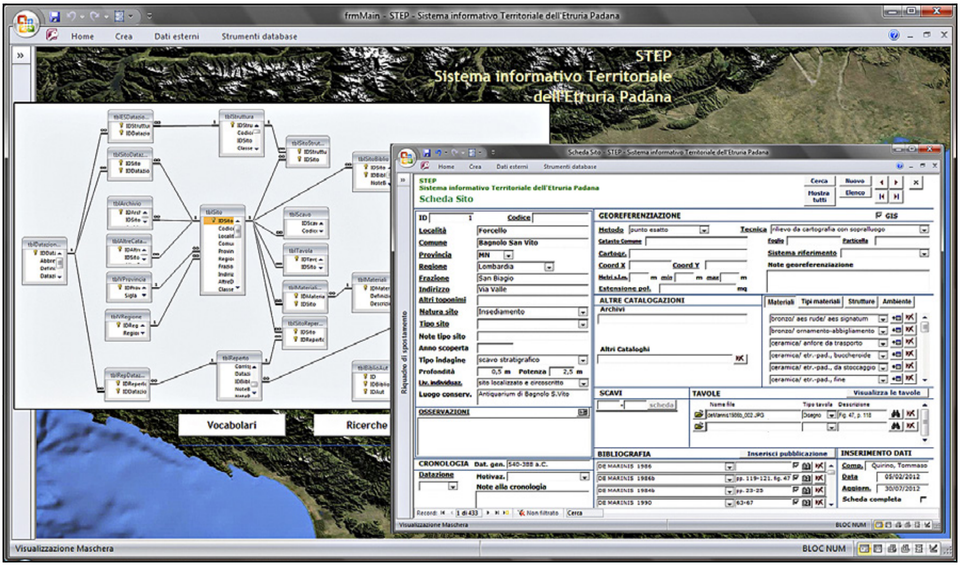

Fig. 1 – Relational schema (left), "Site" form (right) and "Main" form (background) of the RDBMS.

archaeological data in light of the history of research and the landscape data in that of palaeoenvironmental studies (Leonardi 1992, 26-27).

The heart of the information system is the set of files containing the data gathered, more specifically alphanumeric historical and archaeological data relevant to the research: the Relational Database Management System (RDBMS; Fig. 1). The conceptual design, a part of the entire system design, preceded the physical development of the programme and was adapted during data entry as peculiarities of the data emerged. This preliminary analysis led to a simplified conceptual scheme in which I distinguish four primary elements and the relationships amongst them: sites, materials, structures and bibliographic references. The fundamental element is obviously the "site", which represents the basis for territorial analyses and constitutes the principal data layer within the GIS. The site, identified by its nature and its particular type, is considered in the same way as a topographic unit in field survey.

The catalogue currently contains 541 entries, divided into: 234 sites with surface finds, 113 settlements, 116 funerary areas, 11 deposits of material (hoards or votive deposits), 3 pieces of agricultural infrastructure[3], 7 pieces

[3] Sites that have yielded only traces of canalisation for agrarian purposes/irrigation and that are datable to the Later Iron Age (La Tène).

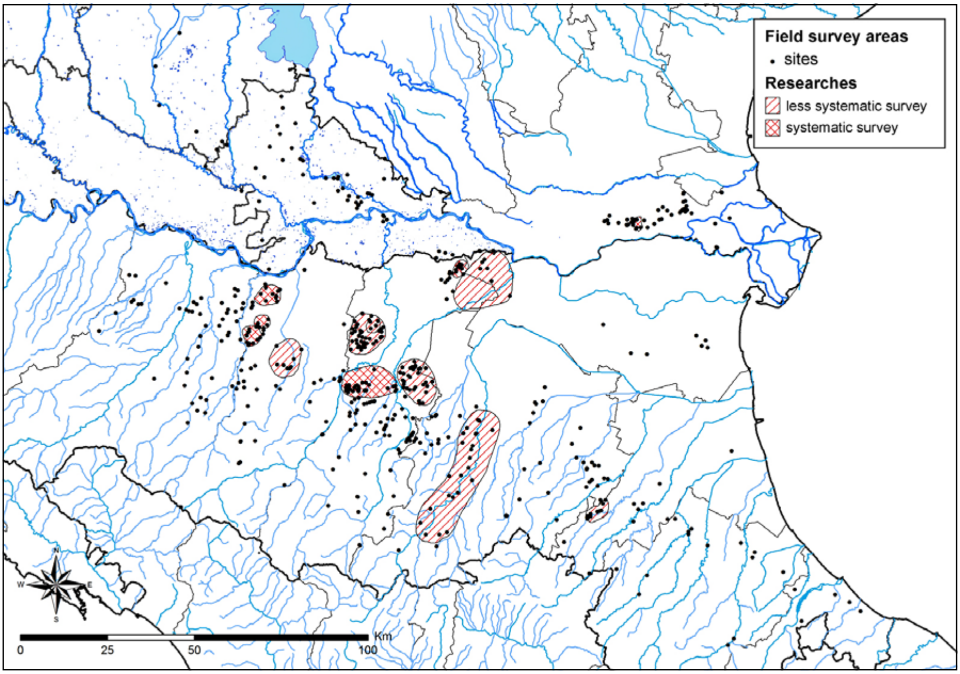

Fig. 2 – Map showing the areas covered by survey projects.

of hydraulic infrastructure (collector wells and drainage channels) and 57 sporadic finds that cannot be interpreted more fully.

Before beginning the process of interpretation, the raw data were analysed to assess their documentary value and the representativeness of the statistical sample gathered. Such analyses helped to identify factors that, independently of archaeological aspects, might influence subsequent spatial analyses: natural post-depositional events, anthropic impacts on the landscape, and the history of research (van Leusen 1996; 2002, chap. 4, 1). In the context of Etruria Padana, we focus in particular on factors that led research to focus on specific areas and natural events that may have affected the reliability of the archaeological record.

First, as the data showed that the majority of the sites catalogued were found as a result of the collection of surface finds, we asked ourselves whether the apparent concentrations of evidence in particular areas might indeed be attributable to greater settlement density or whether it might, instead, result from more or less systematic, intensive and extensive surface research. Creation of a data layer representing the areas covered by survey projects, superimposed on the distribution map of sites, yielded the following results (Fig. 2): areas covered by surface survey represent just 5% of the territory

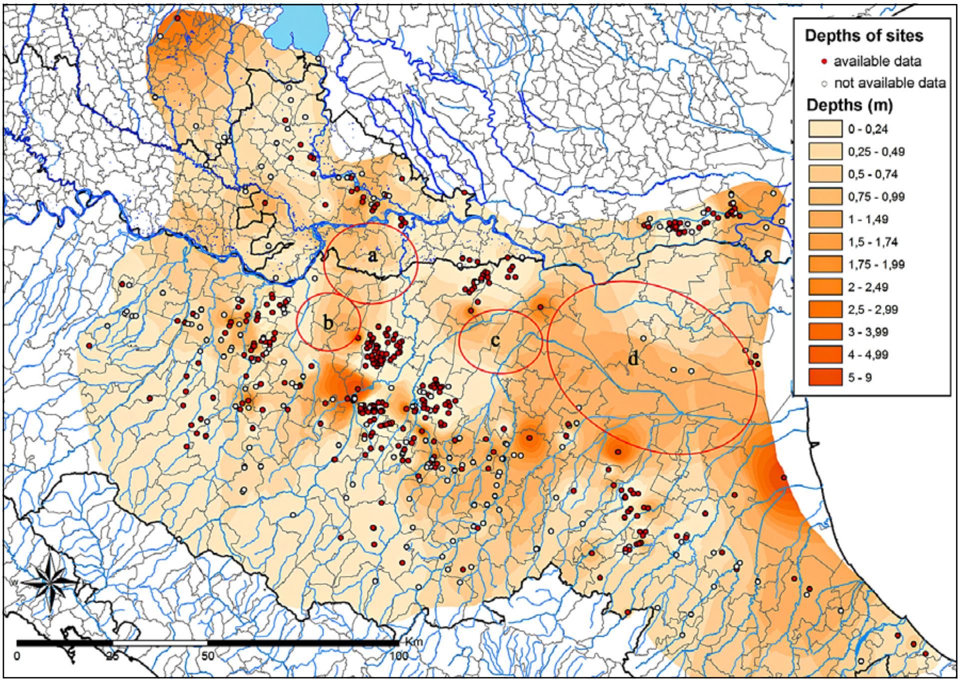

Fig. 3 – Provisional map of the depth of 6th-4th centuries BC contexts.

considered while 195 out of 541 entries in the database (36%) are located in those surveyed areas. It seems clear, thus, that surface surveys have strongly influenced the apparent distribution of sites, which appear as areas of high density. While, in comparison to the areas with low finds density, these areas may be considered anomalous, they may at the same time offer guidance in the understanding of areas currently devoid of data.

At this point, we should also consider the likely influence of alluvial build-up on the identification of buried archaeological remains. It is clear that, in a hydrogeological context such as that of the Po Plain, depositional events may have covered (with alluvial sediments) ancient soil surfaces to varying depths, surfaces that would otherwise have had similar visibility at modern ground levels. To this end, we created a provisional map of the depth of Iron Age contexts (Fig. 3), interpolating amongst the depths at which known sites[4] were reported to have been found in the literature. It emerged that those areas

[4] We employed Inverse Distance Weighting with subdivision into 12 classes using Natural Breaks covering depths between 0 and 9 m (limits determined by the data available). Full data were available for 340 sites. The others, with only plan views available, were excluded.

with few/no finds typically have ancient land surfaces that are deeply buried[5] with four areas being of particular note:

a) The Mantuan Oltrepò and the low Plain around Modena and Reggio Emilia, occupying a large part of the easternmost plain of the meanders of the Po;
b) The middle Plain around Reggio Emilia between the areas of Campegine and Poviglio in the W and Rubiera and Correggio in the E;
c) The low Plain around Bologna and the area W of Ferrara, roughly the zones of San Giovanni in Persiceto, Crevalcore and Cento and thereabouts;
d) The Po Delta from Medicina and Ravenna in the S, Santa Maddalena dei Mosti in the W and the present day course of the Po to the N, where the deltaic deposits and coastal changes have greatly changed the landscape and buried the ancient land surface.

In conclusion, the archaeological sample available for Etruria Padana is rather patchy and discontinuous in terms of the sites known in different parts of the territory. However, there is good reason to believe that the patchiness results more from distortions in the known archaeological record than from the underlying historical reality.

3. Which model for Etruria Padana?

The archaeological data relating to the recorded sites led to an inhomogeneous picture related to the structural aspects of the inhabited centres. They vary in size, internal organisation, the structuring of the surrounding areas and the construction techniques employed. On the basis of these characteristics we can recognise a typology of differing settlements that were, probably, arranged according to a settlement hierarchy. Building on this, we associated a type, a level of importance and a function to those data points on the proposed map that remained, until now, undifferentiated. This association was done on the basis of their known archaeological characteristics.

At the vertex of the system we find, obviously, the city. Above all, there is Bologna, the main centre of Etruria Padana and of continuing importance since the preceding Villanovan period. To Bologna we must add the new, planned cities such as Marzabotto, Spina and Forcello, along with those smaller settlements with a documented (or probable) size of 5-10 ha, such as Case Nuove di Siccomonte. There are then numerous places that we might call secondary (for example Casalecchio di Reno near Bologna and Forte Urbano near Modena) that are characterised by an average size between 1 and 5 ha, by delimitation by a ditch (not always currently identified) and by the presence

[5] We must obviously note that there are also many areas in which the absence of data/finds is clearly – as the map shows – not related to alluvial coverage but requires other explanations that, for reasons of space, are not pursued in the current paper.

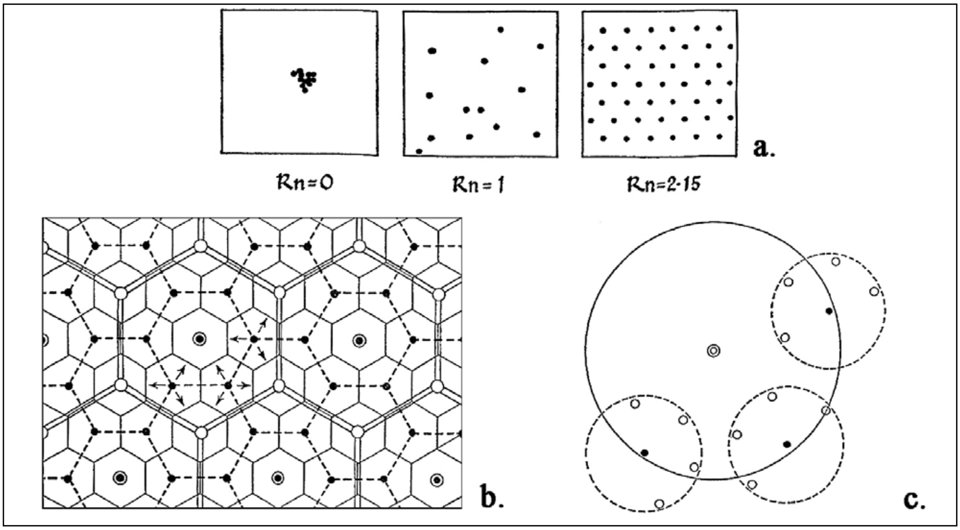

Fig. 4 – a) Settlement patterns corresponding to different values of the Rn index in the Nearest Neighbour Analysis: clustered, random, uniform; b) Settlement pattern with three hierarchical levels, following the Christaller's Central Place Theory; c) The cluster or regular agglomeration model proposed by Kolb and Brunner (Garner 1967, 307, fig. 9.1; 310, fig. 9.3; 311, fig. 9.4).

of numerous habitations, generally on stone or cobble foundations[6]. For these smaller settlements, it has been hypothesised that they were established at the initiative of the regional centre, to look after the interests of its *chora*: rest stops with services, opportunities for exchange and stabling – all social and economic functions that catered equally to the needs of agricultural production and trade (Ortalli 2010, 85). Finally, the smallest centres that characterise a large part of the Plain are those already known in the literature as farms, either single dwellings or small groups of houses, typified by relatively light construction and a location in the agricultural landscape.

The settlement distribution map[7] classified by type now shows a much more complex territorial organisation (Fig. 5). An impressionistic, visual analysis of the map reveals that we cannot discriminate amongst different models either for a given type of site or regarding the relations amongst various types. What we do see is that the data available, whilst abundant and diverse, remain patchy and inhomogeneous. Notwithstanding this constraint,

[6] This last feature, in reality, is not found throughout the low Plain as the materials necessary are often absent.

[7] Sites without sufficient information to define their type are indicated on the maps without specific characteristics and as the class labelled "non-definable". However, they are included in our visualisations of the settlement system.

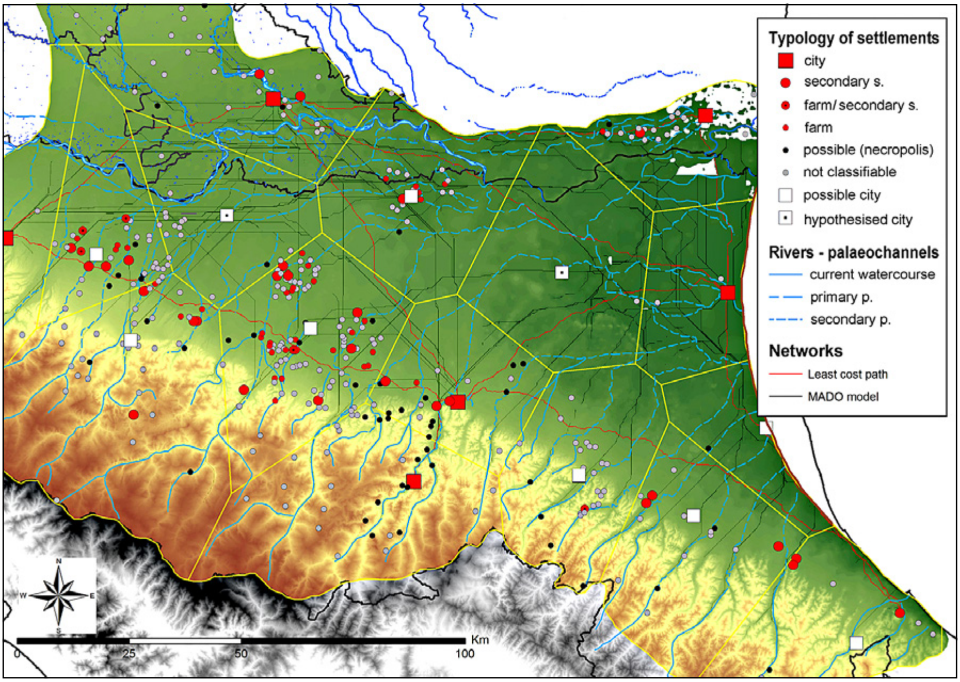

Fig. 5 – Comprehensive map presenting the overlay of all data layers: typology of settlements, territories associated with primary centres (delimited by Thyssen polygons), rivers and palaeochannels, calculated route network.

we will try, on the basis of the distances between the main centres and an hypothesised division of the landscape amongst them, to suggest a model that is likely applicable to Etruria Padana.

A settlement model is based on the general principle that human behaviour usually exhibits certain regularities not only in vertical terms, particularly in terms of hierarchy – of size, structure and economy – that define the relations amongst various settlement classes, but also in horizontal terms, particularly inter-site distance (Garner 1967, 303-304). To quantify – numerically or graphically – the level of dispersion or clustering amongst the catalogued sites we apply Nearest Neighbour Analysis (Garner 1967, 310). This is a calculation of the reciprocal distances amongst points that allows us to measure the presence of structure by means of the value of an index (Rn) that varies from zero – a clustered/agglomerated settlement pattern – to 2.15 – perfectly uniform settlement pattern (Fig. 4, a).

The territory was analysed in its entirety but, given the issues with regards to the representation of the archaeological record, also in geographic blocks so as to minimise the biases that could result from prior research in one area as against another. The entire region is, as one might have expected, shown to be organised according to a clustered plan. However, looking at the different areas we see rather different results. Such diverse results may seem hard to interpret but they actually bring us to recognise a negative conclusion that may well be of use in our reconstructions: in no part of the Plain do we see a perfectly uniform settlement distribution.

Existing proposed archaeological interpretations of the varying classes of settlement and their size, number and location tend to be rooted in the Central Place theory of Christaller[8] (Fig. 4, b) that supposes a type of law governing the distribution. While at first site this might appear appropriate to the current context, Christaller's model is perhaps too abstract and rigid and, above all, supposes a regular settlement grid, something which the Nearest Neighbour Analysis has shown to be absent in Etruria Padana. We need, instead, to look to a model that sees groupings as the result of the attractive power of urban centres, both that based on population and that based on economic factors such as the goods and services that they offered. One such model is the cluster or regular agglomeration model proposed by Kolb and Brunner (Garner 1967, 312-313): the model states that secondary centres will be located at the edges of the areas of influence of the cities, while the minor centres (in our case farms) cluster around the secondary centres at the edges of their own zones of influence, and that the cities will be located centrally (Fig. 4, c). This model, more flexible than the preceding one, is more adaptable to a notably complex social context as it does not specify distances or fixed or predefined directions for the process of settlement distribution. The distances between sites, in this model as in reality, can vary according to the sizes of those same sites.

4. The organisation of the territory and the route network

To check the correspondence between the theoretical model and the archaeological reality described above we now undertake a subdivision of the overall territory into areas associated with the principal centres using the Thyssen polygon method. In our case, the subdivision is based only on the cities, which constitute a homogeneous class of settlements and represent the only centres to which one can credibly attribute control of a territory. The areas thus identified provide a hypothetical zone of influence for each city that would also have been the area supplying foodstuffs to the city's people.

The first problem to be faced in this type of subdivision is the fact that we do not have a complete sample of sites. On the one hand, the ancient sources

[8] In this model, the secondary and minor centres are regularly distributed around the main centres, the cities, in a hierarchical fashion with higher-level sites providing goods and services to lower-level sites.

talk of a group of twelve cities in Etruria Padana, not all of which are known archaeologically. On the other hand, there are extensive areas rich in finds that are not associated with any known urban centre, a centre that should have overseen them. The presence of several urban, or first level, centres in the hierarchy has thus been hypothesised on the basis of various empirical parameters such as the minimum known distance between two urban centres (a little less than 20 km, the distance between Bologna and Marzabotto). That distance was used to create a buffer around each known city, or area under their control, so as to identify areas not under the control of a known site and therefore hypothetically under the control of other, unknown, primary centres. Additional, hypothetical, primary centres were added in these areas on the basis of partial or indirect (e.g. cemeteries) archaeological evidence that suggests the presence of a still unidentified urban centre. Such evidence was required to be of the extent and material richness that one would find in a primary urban centre. The centres added in this way are: Servirola di San Polo d'Enza; Arginone di Mirandola; Montericco di Imola; Villanova di Forlì; Verucchio. Three additional primary centres were also added in areas with little or no archaeological evidence but where it is possible to argue for their existence in correspondence to modern cities (Parma, Modena and Ravenna). Finally, two hypothetical centres were added in areas where the depth of alluvial cover may have rendered them archaeologically invisible: the area around Ferrara and that between the western Mantuan Oltrepò area and the Reggio low Plain.

The map so obtained obviously does not pretend to recreate perfectly the Iron Age reality but instead offers food for thought and a first look at the possible territories around cities and their organisation (Fig. 5). First, there is a reasonably good correspondence with the theoretical model that suggested the placement of secondary centres around the cities but tending towards the edges of the areas under their control. In contrast to the model, however, we also note many secondary centres much closer to the urban centres. This leads us to suggest a more complex form of organisation in which different secondary centres perform different roles and functions: those closest to the cities might be more oriented towards control of access to the city for goods and people, while those further away might be more focused on territorial control, the support of minor centres and the gathering and redistribution of agricultural products. The territories delimited by Thyssen polygons presuppose an isotropic or homogenous landscape without natural boundaries that is equally accessible everywhere. This is a reasonable description of the Po Plain, but not of the Apennine valleys where, with considerable likelihood, the ridges functioned as boundaries between territories.

The picture of the organisation of Etruria Padana offered so far is more static than the reality would have been. The use and exploitation of a territory depends, in fact, on the possibilities for movement that it offers. From the simplest to the most complex human planned environments, the network of connections amongst the settlements performs a fundamental function in maintaining cohesion, being «the true circulatory system of the territorial organism» (Gottarelli 1990, 337). This function is even more important in a network of cities like that of Etruria Padana that was born and founded on commerce, the identification of routes and the exploitation of connections. This network of communication routes does not only include those on land but also those by sea and along rivers. While these latter can be recognised in the network of palaeochannels, it is more difficult to recognise the traces of land routes as documented remains of roads, the construction of which can be attributed to the Etruscans, are very scarce.

In an attempt to reconstruct possible routes we used various GIS analytical functions (Fig. 5). First, we determined the connections between the principal cities through the calculation of optimal paths: those that require the least expenditure of energy to move from the point of origin to the destination. The first step in doing this was the generation of a cost surface based on the slope of the land and the presence of rivers and streams, these latter being an important group of obstacles to overcome – and source of friction resisting movement – in a landscape such as the Po Plain that is not noted for its steep slopes. The hydrography considered was based on the palaeochannels that can be associated with the period of Etruscan presence. Once again, GIS was used to calculate the network of rivers and streams using the flow direction and flow accumulation functions[9]. The network of watercourses thus obtained was then reclassified using Strahler's algorithm (Strahler 1958), which assigns a numerical order to the various watercourse segments in such a way that the different parts present different degrees of obstacle to movement. These two factors – slope and hydrography – were added together to create a single cost surface layer in which slope was given a 30% weight and hydrography 70% in terms of influence on movement. The optimal routes (Least cost paths) between each city pair were then calculated using this cost surface.

To analyse the possible influence of roads and routes on the location of settlements (according to the theory that the communication network might be a factor in locational choices) it was necessary to densify the existing network and complete all connections between all types of settlement. Such a hypothetical network was created using a model proposed in the literature that is known as MADO (the Spanish acronym for *Modelo de Acumulaciòn del Desplazamiento Òptimo*: Fàbrega-Àlvarez 2006; Fàbrega-Àlvarez, Parcero Oubiña 2007, 125). This model is based on least cost movement calculated from a known

[9] The first, working from the DEM (Digital Elevation Model), determines the direction of a hypothetical flow from each cell of the raster, while the second gives the number of cells the flow from which joins together in each downslope cell.

origin but without a particular destination in mind. In other words, given a particular point of departure but not a destination, the model will calculate the possible lowest cost routes leaving that point or, more generally, those optimal routes that might influence human movement. The operational steps in applying this model roughly correspond to those in the creation of the *s*tream network, using the flow direction function that represents the theoretical direction and the flow accumulation function that is otherwise only used in hydrological modelling. Rather than applying these functions to a Digital elevation Model (DEM) they are, instead, applied to a cost surface so as to visualise the directions of flow of movement from high cost cells towards lower cost cells.

As a first consideration, we note that the tracks that connect one city with another do not always correspond to those suggested by this second model. This could be taken to mean that the choice of location for primary centres was not solely driven by landscape considerations but, also, by the need to access specific communication routes at low cost. In this way, commercial routes seem to have guided the settlement of the territory and the strategic location of the centres to which trade goods were brought, and in which those goods were sold, purchased and redistributed.

Across the network, however, one notes that numerous minor centres or those sites whose function is not well understood are distributed near long sections of the hypothesised routes and that several settlements seem to have arisen at the intersections of primary communication routes. An interesting (and difficult to interpret) observation concerns the routes into the foothills of the mountains around Bologna. To the W of Bologna, the road towards the settlement of Case Nuove di Siccomonte is dotted with secondary centres and runs parallel to the Appenines. To the E, on the other hand, the road towards Rimini/Verucchio runs further out into the Plain and does not pass near the documented secondary centres. This result could be, in part, attributable to an erroneous choice of parameters for the cost surface[10]. In part, though, it could also mean that the location of the eastern road that would seem most likely on the basis of the known settlements was not actually that which required least energy but, rather, the shortest or the most suitable for the traffic that it needed to carry.

The road network proposed above does not pretend to be exhaustive and could, for example, be extended with calculations relating to those cities hypothesised but as yet undiscovered. What emerges, however, is that the Etruria Padana system, requiring strong integration and coordination among the cities not only on the economic level but also on the political one (Sassatelli 2005, 241-242 and 252), needed to be supported by a stable and

[10] However, several sets of calculations of the Least cost paths using different weights for slope did not change the results significantly or lead to routes nearer to the known settlements.

interconnected communication network. Only if the entire system worked could the economic systems of the individual cities survive and prosper.

5. Conclusions

All of the information obtained from the analyses undertaken has been integrated into a comprehensive map that presents, in the form of different overlapping and inter-comparable data layers, a snapshot of a hypothetical settlement model for Etruria Padana (Fig. 5).

The distinctive qualities of this model can be briefly summarised (using several technical terms from Etruscology: Colonna 1988, 30-36). The overall structure is based on the cities (*methlum*), to which political and economic control of the territory is ascribed. The cities serve as demographic beacons, attracting incomers, and contain the workshops of specialised craftspeople. Most of their inhabitants make their living through commercial activity. Each city – which in this sense we regard as being at the same level in the hierarchy – has its territory that houses, in various types of settlement, the community associated with that city (*spura*). Here one finds minor centres, farms that provide agricultural produce both for themselves and the people of the city (and, perhaps, also for export), and secondary settlements. These latter are located near the city or near the limits of its territory. They are settlements of medium size, primarily residential and occupied by people of a certain rank. Their function can be interpreted in various ways: as centres for gathering and redistributing agricultural products, as rest stops along the main commercial routes, and as points of control over the goods and people that circulated in their area of control (*tuthina*?). All these diverse types of settlements, connected to one another by a dense and complex route network, are united by their proximity to rivers and streams, used both as a communication route and as a fundamental resource for agriculture.

This model of the settlement system does not pretend to completeness. We are aware that the reality must have possessed a degree of complexity that we cannot comprehend with the data at hand and by means of the analyses undertaken to date[11]. What we do have, however, is a first concrete visualisation of the system. The settlement system of Etruria Padana now has a geographical and cartographic base that represents a point of departure for new thought and analysis that may confirm it or, indeed, may amend it.

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[11] From which, to date, we have excluded those aspects related to the political organisation of the Etruscan people.

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ABSTRACT

The Po Valley was occupied by the Etruscans starting in the 9th century BC. This presence experienced a significant transformation from the mid-6th century BC, when the territory underwent a widespread colonisation process, which brought about a new pattern in the organization of the landscape. A network of farms and secondary settlements appeared and expanded around both old and new cities. Through the structuring power and the analytical

potential of GIS, this research develops new perspectives on the reconstruction of the ancient landscape. In addition to cultural aspects closely related to Etruscan society, in this study we have taken into consideration the role played by the resources of the territory itself, both from economic and the transport network points of view. First, we briefly present the conceptual and physical structure of the GIS. It includes an archive of all the known sites N of the Apennines (541), dating to between the 6^{th} and 4^{th} century BC (managed in a relational database), and a set of geographic and thematic data of general interest, recorded in the same cartographic reference system, handled with GIS software. Second, on the basis of certain distinctive characteristics of settlements such as the size of the occupied area, the internal organization and the building techniques employed, a possible hierarchical subdivision of the settlements is identified. Further, the optimal pathways between major cities are hypothesised considering factors such as slope and the presence of rivers or streams, and a possible road network is calculated using the MADO model (optimal accumulation model of movement from a given origin). The final aim is to propose a settlement model that can then be compared to the reality of the current archaeological record.