pca

european journal of
postclassicalarchaeologies

volume 3/2013

SAP Società Archeologica s.r.l.

Mantova 2013

pca

Post-Classical Archaeologies (PCA) is an independent, international, peer-reviewed journal devoted to the communication of post-classical research. PCA publishes a variety of manuscript types, including original research, discussions and review articles. Topics of interest include all subjects that relate to the science and practice of archaeology, particularly multidisciplinary research which use specialist methodologies, such as zooarchaeology, paleobotanics, archeometallurgy, archeometry, spatial analysis, as well as other experimental methodologies applied to the archaeology of post-classical Europe.
Submission of a manuscript implies that the work has not been published before, that it is not under consideration for publication elsewhere and that it has been approved by all co-authors. Each author must clear reproduction rights for any photos or illustration, credited to a third party that he wishes to use (including content found on the Internet). Post-Classical Archaeologies is published once a year in May, starting in 2011. Manuscripts should be submitted to **editor@postclassical.it** accordance to the guidelines for contributors in the webpage http://www.postclassical.it
Post-Classical Archaeologies's manuscript review process is rigorous and is intended to identify the strengths and weaknesses in each submitted manuscript, determine which manuscripts are suitable for publication, and to work with the authors to improve their manuscript prior to publication.

For subscription and all other information visit the web site http://www.postclassical.it

DESIGN
Paolo Vedovetto

PUBLISHER
SAP Società Archeologica s.r.l.
Viale Risorgimento 14 - 46100 Mantova
www.archeologica.it

PRINTED BY
Tecnografica Rossi, Via I maggio, Sandrigo (VI)

Authorised by Mantua court no. 4/2011 of April 8, 2011

ISSN 2039-7895

pca
european journal of
postclassicalarchaeologies
volume 3/2013

CONTENTS PAGES

DOSSIER - EMERGENZA, TUTELA E CONCESSIONI DI SCAVO IN ITALIA

RETROSPECT

PROJECT

REVIEWS 357

PCA 3 (2013) ISSN: 2039-7895 (pp. 171-197)
European journal of Post - Classical Archaeologies

beyond the theme

Spatial calculations and archaeology: roads and settlements in the cases of Valdorcia and Valdarbia (Siena, Italy)

STEFANO BERTOLDI

Università degli Studi di Siena, Dipartimento di Studi Classici, via Roma 56, 53100 Siena.
stefanobertoldi2002@yahoo.it

The study examines settlement dynamics and their transformation between the 1st and 10th centuries in Valdorcia and Valdarbia. Statistical analysis through GIS showed that the 3rd and the 6th centuries were periods in which the settlement pattern changed profoundly. These changes are visible even in spatial terms, through the transition from the Cassia to the Francigena.
Keywords: least-cost path, Roman road network, rank-size rule, spatial analysis

Lo studio è finalizzato ad esaminare le dinamiche insediative ed i loro cambiamenti tra I e X secolo d.C. in Val d'Orcia e Val d'Arbia. L'analisi statistica in ambiente GIS ha evidenziato il III ed il VI secolo come periodi in cui il tessuto insediativo cambia profondamente. Questi cambiamenti sono leggibili anche in termini spaziali nella viabilità, nel passaggio dalla Cassia alla Francigena.
***Parole chiave**: least-cost path, viabilità romana, rank-size rule, analisi spaziali*

1. Introduction

This work focuses on the study of road networks between Late Antiquity and the Early Middle Ages in the Orcia and Arbia Valley[1] (fig. 1). At the same time it wants to highlight the link between roads and settlements networks, especially regarding the attraction power of the first on the latter.

[1] The research concerns the districts of Monteroni d'Arbia, Buonconvento, Pienza, Montalcino, Castiglione d'Orcia, San Quirico d'Orcia and San Giovanni d'Asso.

Received: 09-11-2012 - Accepted: 24-11-2012 - Revised: 18-03-2013

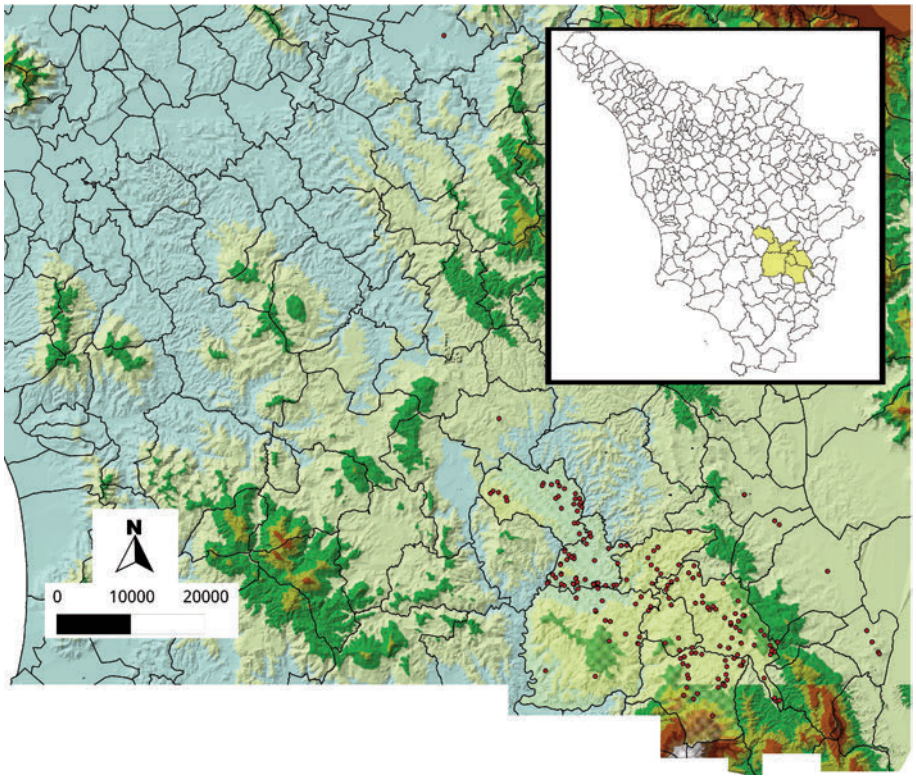

Fig. 1. The area covered by investigation. Monteroni d'Arbia, Buonconvento, San Giovanni d'Asso, Montalcino, Pienza, San Quirico d'Orcia and Castiglione d'Orcia are highlighted in yellow.

In an archaeological study of a territorial district, the analysis of road networks has to be seen as a primary tool in order to achieve an understanding of the anthropic spatial organization, yielding information on important subjects such as the change and deviation in road systems, the planning and building of new roads, the lifecycle of auxiliary structures such as horse-switch stations and the exact localization of entire areas of ancient landscapes. Together, these themes offer us the fingerprints to detect continuity and discontinuity between the late antique and the early medieval periods (Volpe 1996, p. 59).

The aim of this work is to propose a settlement pattern based on quantitative data. This pattern should be able to summarize the archaeological complexity in order to reach statistical models that become employable in spatial and diachronic terms.

2. Research strategy

In attempting to achieve these aims we will look into the application of spatial and statistical analyses based on archaeological data (excavations and surveys) and involving also the known written sources[2].

The conceptual base that backs up the whole work is the systems theory, according to which in a determined set all the elements are interacting with each other. Depriving a system of its interactions means reducing it to one single set. The definition "General System Theory" (GST) originates from Bertalanffy's work in the late 1960's (Von Bertalanffy 1968). In archaeology the development of methodological reflection on GST is mainly owed to the theoretical intuitions of the processualist researchers, in particular Renfrew and Clarke (Clarke 1968, pp. 43-72).

One fundamental issue of the theory is related to the internal balance. A system can reach several different types of equilibrium at different stages: it can be stable, unstable, metastable, constant, dynamic etc. Basically, a system can destabilize and then change its appearance; it can get into a crisis or break as a result of internal or external events. Archaeological systems are continuous and, if not affected by changes, have a limited activity of variation. A change in the system, which can lead to a modification its nature, will show some traits that can be observed, determined and quantified.

Communication routes of any nature and material consistency have always been a necessary mean to favor and promote human interactions. In this sense they have to be understood as an almost perfect demonstration of the systemic nature of human action on the landscape. Clearly, discovering the reasons that caused choices made in the past is, of course, very difficult. The process that led to a decision may, in itself, be systematized in two consecutive moments. The first of them is the deliberation: those who have to make a decision, analyze all different alternatives and evaluate each of them. The second step is the choice, meaning that one of the options will be selected. In cases of uncertainty, when it is impossible to discern with absolute confidence the right or the wrong choice, there are a few tools available that can help the researcher to pick one of the alternatives. Having this decision-making system[3] in place allows us to choose from a set of options. The problem in choosing a set of variables, beyond their correct

[2] One of the first scholars dealing with spatial methodologies in archaeology was Clarke, who wrote "Analytical Archaeology" (Clarke 1968, published in Italian 30 years later); of similar importance is Hodder and Orton's essay "Spatial analysis in archaeology" (Hodder, Orton 1976).

[3] For a discussion on decision-making system see Lu *et alii* 2007.

quantification, lies mainly in the fact that there is a difference between the old concept of space and the modern one. This difference can be essential.

Being supported by a calculator to define what is more likely (or, if it's the case, to carry out a "fuzzy quantification") can generate wholly new points of view in research; without neglecting all the limitations of the systems itself, we are simply able to obtain a clearer image of data on a specific territory.

3. Working methodology

The GIS analysis of routes is included in the decision-making system category. It gives us the possibility of calculating lower energy costs from a point A (origin) to a point B (destination) (fig. 2). During the 1990's, this kind of analysis has been a subject of discussion, focused on its usefulness or unsuitability in the archaeological study of a territory (Gietl, Doneus, Fera 2008, p. 342).

The GIS algorithm, which designs the route, is mainly determined by the direction from the origin point to the destination point. Beyond this, many other criteria (altitude, hydrography, slope and poles of attraction and so on) can be taken into account by the software, according to a scale of values defined by the user.

The major issue with this type of analysis is the ability of calibrating all variables and their value classes in order to have a system as logical as possible and above all, capable of reflecting anthropic processes which, unlike natural or physical phenomena, in certain circumstances may indeed go beyond rational choices.

The second element that has to be taken into account is the use of logical differences among the reasons that lead us to do some analysis and the ways in which we apply them. In the least-cost path analysis, the computer is programmed with a correlated value scale set by the user and it therefore picks a logical decision using our inputs and criteria. In an archaeological application of this system, the cognitive process must go in the opposite direction, considering that a road has been built before its constructive principles are known.

For example, assuming that the choice of a path has been made on an economic basis, within the broadest sense of this term, the GIS software will select the hypothesis that corresponds to our condition/assumption. If we could verify the reliability of our test and so discover that the results we have obtained do not match the real route, we still couldn't blame the wrongness of our tools, but much rather an incompatibili-

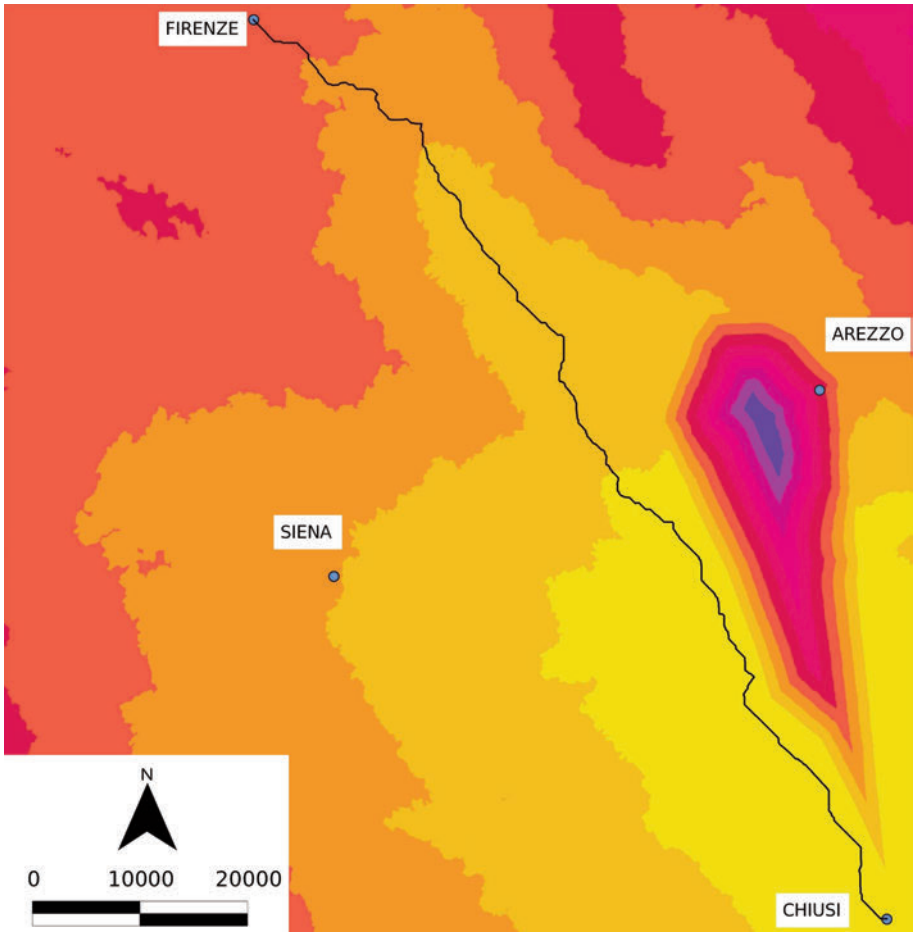

Fig. 2. Least cost path analysis: cost-raster between Chiusi and Firenze and the vector generated from the least cost path.

ty between the variables taken into account by those who built the road and the ones chosen by the researcher. So, an error in selecting the variables will almost certainly lead to an error in the results we get (Gietl, Doneus, Fera 2008, p. 8).

Another type of analysis we have used is the rank-size rule, a geographical pattern that applies to the population of a territory[4] (fig. 3).

[4] For a description of the dimensional rank rule see Cambi, Terrenato 1994, pp. 243-247 and Macchi 2009, pp. 114-123. A recent use of this methodology on the medieval territory of Grosseto can be found in Farinelli, Olivelli 2009, pp. 167-178. George Kingsley Zipf already perceived the universal relationship in the development of population systems, but the first one to formulate the theory was Felix Auerbach (Auerbach 1913, pp. 74-76).

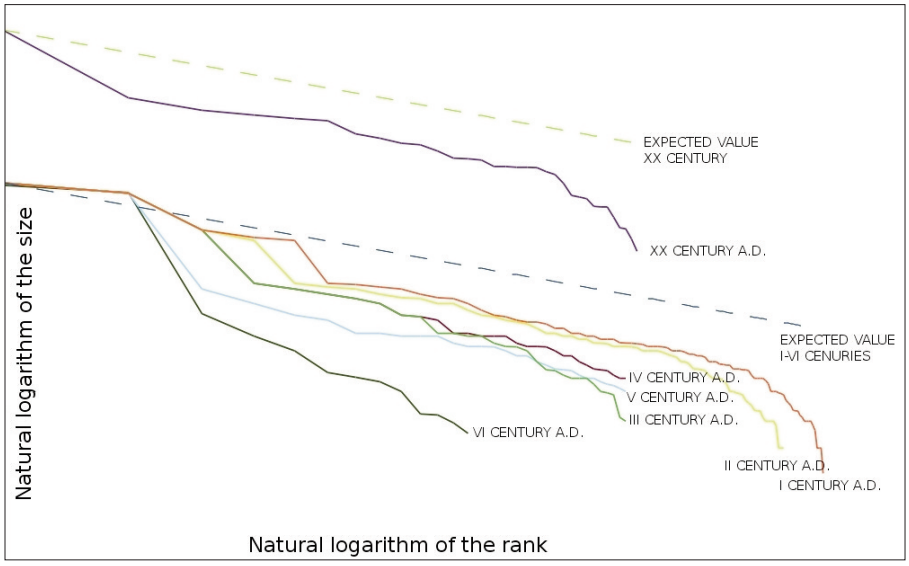

Fig. 3. Rank size rule: chart for 1st-6th centuries in comparison with 20th century.

The simple principle behind it is that in a given territory, where urban and rural settlements are ordered hierarchically, the population of each center will correspond to the population of the bigger center divided by the rank of the settlement in the hierarchic scale. The basic assumption of the model is clearly that all settlements are linked by some kind of constraints, showing the systemic nature of human settlement. This model describes the systems of the urban population, but also is effective at lower levels, allowing us to apply it to rural contexts.

In archaeology a strict application of this geographic model can be extremely difficult, due to the inability of obtaining complete information on the ancient population networks of wide territorial contexts. In order to counterbalance this problem it has been proposed to use the dispersion area of finds on a site as a variable, instead of the global population data[5]. The rank-size rule certainly shows some conceptual limitations: first of all it is a theoretical model that summarizes the reality in a very strict way; secondly it poses a geographical problem in the choice of the limits to be adopted in its application. There are also some other doubts

[5] This methodology was proposed for the first time by G.A. Johnson (Johnson 1978; 1980a; 1980b) at the end of the '70s and it was presented again by A. Guidi (Guidi 1985), who applied it in 1985 to the southern Etruscan and *Latium Vetus* settlement network in the period from 1200 to 700 BC (and later also on other contexts).

in the archaeological application of this model, for instance the lack of certainty in the proportional correspondence between the population and the finds dispersion area, as well as all the issues related with archaeological visibility (Cambi, Terrenato 1994 p. 151).

But, despite these methodological limits, we have to consider the opportunities that the rank-size rule can offer. First of all, since it is based on a theoretical model, we have to look more at the differences between the expected and the observed curves, rather than at the similarities; these incongruences can be more easily inferred to historical reasons.

4. The investigation: routes and settlements

During the Roman Empire, the construction of a road was an event of maximum relevance[6], considering all the economic factors that were involved (in fact, it is something not too difficult to imagine even for us, thinking of modernity).

Another element showing a thorough planning of the work is the fact that, in the vast majority of cases, the paved stretches of Roman roads have been discovered between the 19th and the 20th century during the construction of modern roads or railways. This tells us how the ancient perception of the territory (at least in these cases) was not very different from ours. The minimum aspects which had to be taken into account were hydrography, soil morphology and the presence of facilities/infrastructures[7].

The main feature of the Cursus Publicus is the sequence of road infrastructure calls Mutationes or Mansiones (Corsi 2000, pp. 15-19); these places could be cities, rural settlements (for example *vici*) and villas.

The sequence of events that begins with the construction of a road, continue with life and with any changes, ends with the abandonment, is much less linear to what has been schematized.

4.1. The Cassia and the Via Francigena

Among the sources used in the analysis of the road system between Siena and Chiusi we could not get along without the Tabula Peutingeriana

[6] In this paper we will not write about the well-known building techniques of roman roads; on the subject see, above all, Radke 1981, pp. 47-59.

[7] In order to understand the basis for the construction of these infrastructures see Annunziata *et alii* 2004 and Annunziata, Cerere, Coni 2007.

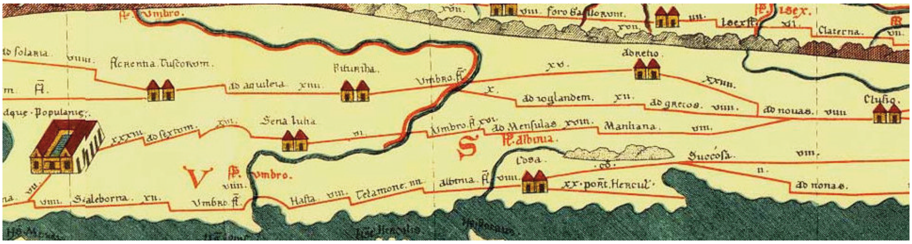

Fig. 4. Detail of the Tabula Peutingeriana that shows the passage of Cassia in Tuscany, intermediate mansiones and distances.

(Levi, Levi 1978) as a constant reference (fig. 4). As regard the other sources about Roman roads, the *Itinerarium Antonini* omits the *diverticulum* from Siena to Chiusi, the *Ravennatis Anonymi Cosmographia* and the *Guidonis Geographica*, show approximately the same succession of the Peutingeriana.

The area covered by this contribution, in the last 10 years has been involved in investigations for the project Carta Archeologica della Provincia di Siena, and in addition to the archaeological survey were considered aerial photographs, written sources, historical maps and toponymy.

Proceeding northwards after passing Chiusi, the document shows a first *mansio* called pictur*ad Novas*, at a distance of about 13.3 km. At this point the road splits in three axes that are directed respectively to Florence, Arezzo and Siena. The branch moving towards Arezzo joins the main stretch before Florence, probably in the Valdarno, while the third, after surpassing *Sena Julia*, ends up forming a road network connecting with the Aurelia and therefore heading towards the Tyrrhenian coasts (for Cassia in general, see Mosca 2002).

On this last route, after passing *ad Novas* and going on for about 11.8 more kilometers, there is a second *mansio* called *Manliana*. Then, the *Tabula* reports *ad Mensulas* at a distance of about 26.6 km and *Umbro flumen* at 23.6 km, in order to finally reach Siena after 8.8 km.

The last distance leaves us puzzled: it is known that the Ombrone is not so close to Siena and the closest point between the river and the city, represented by its source, measures 16.6 km. In fact, the Ombrone, from its source to La Befa, has proven to be at a roughly constant distance from Siena, between 17 and 23 km[8]: so it is right in this area that we should find the *Umbro Flumen* mansio.

[8] The measure, as the others reported in this paragraph, has to be understood as direct distance.

Among the various proposals put forward by scholars from the 19th century to date, regardless of the locations of *mansiones*, three routes can be outlined: a southern detour through the Val d'Orcia and the Val d'Arbia, a northern detour through the Val di Chiana and an intermediate solution.

The southern deviation is the oldest one among these alternatives and has to be analyzed from a coherent point of view: as a matter of fact it is very unlikely that the branch of Siena, once it parted from the Hadrian's Cassia (direction Florence) close to Montepulciano, would run parallel and close to the main road for about 30 km. The cogency of the second interpretation is heavily influenced by the parish of Sinalunga, called San Pietro *ad Mensulas*. This hypothesis has been later completed by excavations at Pantani Le Gore, a *mansio* interpreted as *Manliana* by considering both the distances on the *Peutingeriana* table and the toponym of the hill (Magliano).

A compromise solution, enunciated by Miller (Miller 1916, pp. 295-296) and then resumed in some respects by Maroni (Maroni 2001, pp. 15-104) and Patitucci Uggeri (Patitucci Uggeri 2009, pp. 373-380), represents a more complex road network: although the path shown by the *Peutingeriana* is considered to be the one passing through the Chiana valley, the indicators from Valdorcia are too strong (not last, the continuity with the Francigena road) not to think of an important road already existing during the Imperial Ages. In a general reconstruction perspective, this point of view is probably the most consistent one; moreover, it must also be taken into account that the two hypothesis may not contradict each other. So, if the road system of Miller seems the one which best suits the complexity of the area, it is not absolutely convincing in some of its parts; especially in its need to break the linearity of the path as it is represented in the *Tabula Peutingeriana*, without explaining why in an exhaustive way, but merely taking examples of obvious mistakes in other parts of the map. With such an approach, the painted document does not become a tool of comparison with the reality of the territory; on the opposite, it turns merely into an element of justification to be used only when hypothesis coincide and to be passed over in silence in all other circumstances. If there is no doubt that the *Tabula* does not represent a true image of reality, first of all we need to understand which errors can be certified (and are therefore sure); then we have to isolate the likely ones for which it is difficult to prove a truthfulness of the document and, finally, the possible ones, deducted from our own interpretations.

Analyzing the paper, it is clear that the pattern of the road network is correct (except for a few mistakes), that the succession of the *mansiones* is in the great majority to be considered reliable and that, instead,

the indicated distances may be wrong (interpolated, omitted, fallen, added or confused) (Quilici, Quilici Gigli 2003, footnote n. 69, p. 196).

The route-network proposals that are more convincing and that we will here describe in some detail are those made by Lopes Pegna (Lopes Pegna 1953, p. 428) and Gamurrini (Gamurrini 1898, p. 274); the first author describes a network that insists on the Chiana valley, while the second scholar proposes a route extending between Valdorcia and Valdarbia. The two scholars do not upset the pattern indicated by the *Peutingeriana*, but curiously, despite the use of a very similar approach, they come to two diametrically opposed conclusions.

Lopes Pegna places *ad Novas* in Acquaviva di Montepulciano, *Manliana* near Torrita di Siena, *ad Mensulas* in Sinalunga and *Umbro Flumen* in Rapolano. The distance shown in the *Peutingeriana* between Chiusi and *ad Novas*, as we have already said, is about 13.3 km, while in reality the distance between the two locations is about 12.8 km; the error is -4%, a gap close to zero[9]. For the branch of road *ad Novas*-Manliana, the *Tabula* shows a distance of 11.8 km, to be related with the 10 km that separate Acquaviva di Montepulciano from Torrita di Siena: the error we get is significant (-15.3 %), but it is still widely acceptable. For the next segment *Manliana-ad Mensulas*, the distance shown on the ancient map is 26.6 km, while the real measure between Torrita di Siena and Sinalunga is 4.9 km, with an error of -81.5%. The section *Mensulas-Umbro Flumen* is reported as 23.6 km, while the distance between Sinalunga and Rapolano is only 15.4 km (-34.7%). The last distance (one that however is more liable to error), from *Umbro Flumen* to Siena, is 8.8 km on the map and 21.4 km in the reality, so we have an error of 143%.

Gamurrini instead identifies only the *mansiones* of *ad-Novas*-Acquaviva di Montepulciano and *ad Mensulas*-Matrichese. The sum of the distances *ad Novas-Manliana* and *Manliana-ad Mensulas* is approximately 38.4 km on the *Tabula*, while the measured distance between Acquaviva di Montepulciano and the Matrichese Hill is 30.5 km (originating an error of -20.6%). Proceeding in the traced itinerary, the sum of the distances *ad Mensulas-Umbro Flumen* and *Umbro Flumen-Sena Iulia* on the *Peutingeriana* is approximately 32.4 km, very close to the measured distance between Matrichese and Siena (31.6 km, with an error of only -2.5%). If it is true that the author greatly simplifies the road system, identifying only one of the three uncertain *mansiones*, it has also to be said that his path appears to be incomparably the most coherent one.

[9] The percentage error is given by the ratio observed value/expected value.

The calculation of routes is a different type of evidence that can be used in the reconstruction of road-networks. In our analysis we decided to start from a TIN (Triangulated Irregular Network) map, a network of irregular three-dimensional triangles with shared vertices generated by contour lines (in our case with a pitch of 50 meters, whose coherence has been checked on Google earth). The TIN has been used to generate a raster slope map in degrees with 30x30 m grid-cells and a higher resolution map (10x10 m grid-cell) based on a 25 m buffer zone around the course of the main rivers (Arno, Chiana, Ombrone, Orcia and Arbia). Once created, the two rasters were added up; a value between 0 and 90 has been assigned to the slope, while a value between 0 and 20 to hydrography (normalized on a scale of only two values: 20 to be assigned to pixels within the buffer area and 0 in the rest of the map)

The resultant raster cartography has firstly been used in tracing what has to be considered the oldest major road, the *Cassia Vetus*, going from Chiusi to Florence passing through Arezzo. The second road axis that has been calculated is the *Cassia Nova*, which is dated to AD 123 by the milestone of Montepulciano and is supposed to connect Chiusi and Florence, cutting out Arezzo. Following this hypothesis, a mask has been added to the previously calculated raster, in order to exclude the northern area of the Val di Chiana and the Val d'Arno close to Arezzo, meaning in this way impose an absolute repel factor; this has been accomplished by imposing a very high cost to this area, with values ranging between 52 and 89 (on a scale from 0 to 89). Actually the track obtained turned out to be shorter of about 17% than the one passing through Arezzo. The third operation performed on the GIS has been the calculation of the road that was supposed to connect Chiusi to Siena; this caused a new mask to be added in order to "hide" the eastern area of the road previously drawn between Chiusi and Florence. For this area, in addition to the start- and endpoints (Chiusi and Siena), we also have an intermediate feature represented by the Ombrone. The river has been used as the source line and with the cost-value raster that has so been obtained, it has been connected to Chiusi and Siena. The result is not easy to read, given the fact that, using the parameters we just described, the generated track is not logically coherent and the points on the Ombrone are separated by 22 km in direct distance. But, in fact, the obtained routes correspond roughly to the interpretations of Gamurrini and Lopes Pegna.

The calculation of the paths allow us to add additional data to the considerations that can be made on this road: if we consider the total distance indicated in the *Peutingeriana* to reach Siena from Chiusi we ob-

tain 82.2 km, a value that does not allow to exclude the validity both of the northern (80.4 km) and of the southern (84.9 km) route. The distance between Siena and the river Ombrone in the two hypothesis is the same (27.1 km) and very different from that indicated by the *Tabula*, (8.8 km, as we said before). In order to justify this accepted error, it can be assumed that the scribe of the "*itinerario picto*" (the painted route) operated an interpolation mistake, exchanging the distances Siena-Ombrone and Ombrone-*ad Mensulas*. In this way the value to refer to would be of 23.6 km, with an error of 13%. Accepting this hypothesis and the consequent inteprolation, the distances have to be inverted and the second *mansio* should be about 8.8 km away from *Umbro Flumen*. In the northern itinerary, *ad Mensulas* should be the identified with the parish church of Sinalunga, as in the route designed by Lopes Pegna; this would give an actual distance of 20.4 km[10].

The route through the Arbia and the Orcia valleys, on the other hand, has to be fully understood: *ad Mensulas* could also be detected in Torrenieri. The place is mentioned in the list of Sigeric, between *Arbia* (Ponte d'Arbia) and *Sce Quiric* (San Quirico d'Orcia); it might therefore be an appropriate location to reconnect to a road. The distance between the crossing on the Ombrone (assuming it corresponds to the bridge of Buonconvento, just north of Santa Cristina *in Caius*) and Torrenieri is 9.5 km (with an error of 7.4%). The northern road, once it has passed the parish church of Sinalunga, arrives at Torrita di Siena (identified with the *mansio Manliana*) after about 5.1 km, while the distance shown in the *Peutingeriana* is 26.6 km: although we can not speak with reasonable certainty of a mistake, as in the previous case, it is however possible that here we have another interpolation. But even if we accept this hypothesis, the statistical error is still highly significant (131%, since the interpolated distance is 11.8 km[11]). If we analyze the same road stretch in the light of the second hypothesis, *Manliana* can be identified with the site of Campi Rutiliani interpreted as a settlement/*villa*, getting a distance from Torrenieri of about 11.6 km (an error close to zero).

Returning to Lopes Pegna, for the section from *Manliana* to *ad Novas* we have to use the previously interpolated value of 26.6 km, derived from the *Peutingeriana* and referred to the distance between *ad Mensulas* and *Manliana*; since the real distance between Torrita di Siena and

[10] The measurements were made on the basis of the route generated by the least-cost path GIS analysis.

[11] Interpolation has been used again in this case, in relation to the fact that other possible errors seem to be less probable.

Acquaviva di Montepulciano is of about 11.3 km, we have an error of 135%. From Campi Rutiliani, to reach *ad Novas*-Acquaviva di Montepulciano we have to run about 20.2 km, getting another error of 31.6% (fig. 5).

A further indication can be obtained by correlating the *diverticulum* we are here discussing with the track of the main Cassia heading to Florence: if we accept the northern hypothesis, the two roads would run parallel for 9 km with only 3 km of distance between each other and for another 20 km they would remain at a maximum distance of 9 km. It is very unlikely that two probably contemporary parallel stretches were planned so close to each other; building a single road and slightly diverting the itinerary to the north would have been a much more convenient option.

Between the end of the 6th century and the first years of the 7th century a new route starts to develop, the Via Francigena. It has not to be understood as a single road built in a single moment in time; it resembles much rather a network of paths going through Italy from north to south and heading towards Rome. For the reconstruction of this new track we

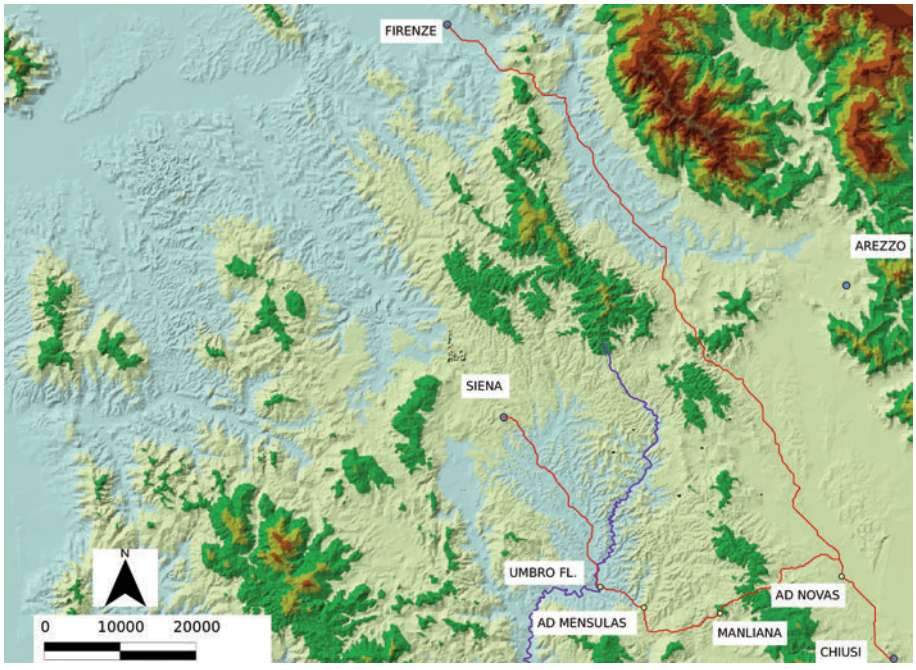

Fig. 5. Reconstruction of the road Siena-Chiusi and identification of intermediate mansiones.

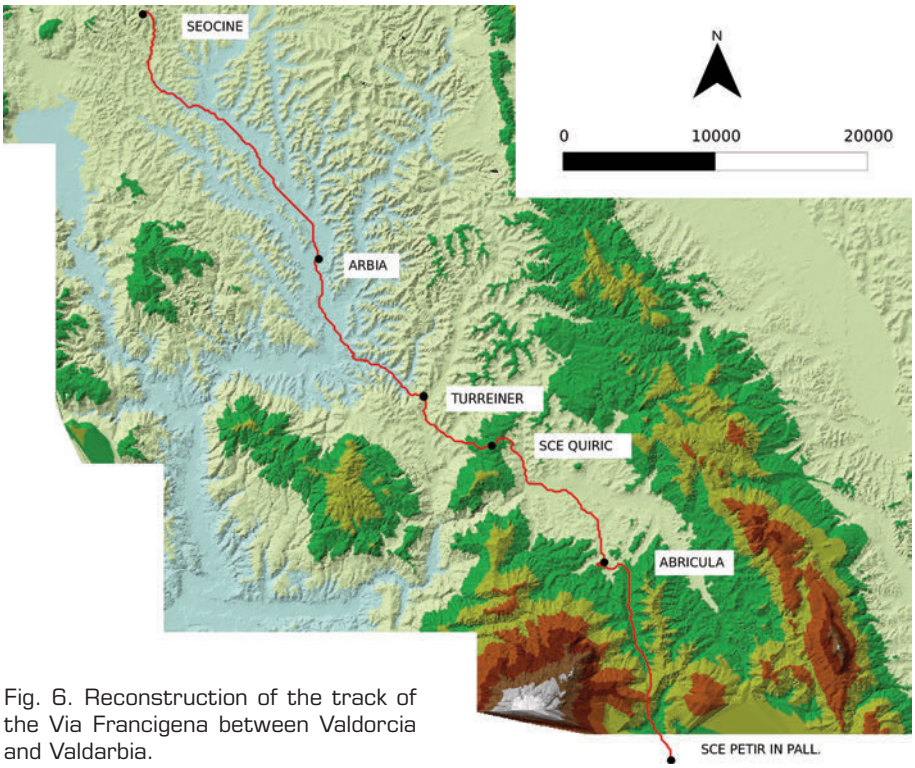

Fig. 6. Reconstruction of the track of the Via Francigena between Valdorcia and Valdarbia.

have an invaluable tool, the Sigeric Itinerary. The future archbishop of Canterbury grew up in the Abbey of Glastonbury as a pupil of St. Dunstan. In AD 990 he undertook a journey to Rome with the intention to receive the *Pallium* (a narrow band decorated with crosses) by Pope John XV. Several predecessors of the archbishop had made the same journey to Rome (the first being St. Wilfrid in AD 657), taking the pilgrimage *ad limina Apostolorum*.

On his way back Sigeric[12] pinned all the intermediate stages, which he calls *submansiones*[13]: not only cities and villages are listed, but also all the places where travelers could rest, eat and spend the night. Leaving aside the part of the itinerary regarding the region of Lazio, starting

[12] The text is integrated into the life of St. Dunstan, along with a list of popes starting with AD 989.

[13] The term is not clear. It replaces the word *mansio* and it could simply mean that Sigeric had some knowledge of the *cursus publicus*. Another hypothesis is that *submansiones* have to be linked with the term *submanentes*, indicating places that provide temporary shelter.

from Aquapendente the track passed by the churches of St. Peter and St. Benedict and went forth to *Sce Petir in Palia*, a site now undetectable but attested in written sources since AD 811. At the same time of the Sigeric's voyage, to be exact in AD 995, the place is cited as *curtis*. Although the location currently does not show any material evidences, we know through historical and cartographic sources that at least until the 17th century there used to be a settlement called Paglia (Mambrini, Stopani 1989, p. 304). From here it was possible to get to at *Abricula*, corresponding nowadays to Le Briccole, a long-term site interpreted as *villa* from the 1st century BC to the mid-5th century AD. After its abandonment we have traces of a reoccupation phase the during the 6th and 7th centuries, probably with the building of perishable material structures. In the 8th century a *Hospitalis S. Pilgrims Obricolis* is documented, where Sigeric, Gregory VIII, Arnold of Brescia, Philip Augustus and Charles of Anjou halted. During the 9th century there is evidence of a new phase of occupation, lasting at least until the *submansio* attested by Sigeric at the end of the 10th century.

Leaving behind Le Briccole, the Archbishop of Canterbury arrived in *Sce Quiric*, San Quirico, where the church of S. Vito Osenna is identified, one of the religious buildings at the center of the dispute between the dioceses of Siena and Arezzo in AD 714. In Torrenieri, a settlement mentioned for the first time in the itinerary of Sigeric, the Francigena joined up with the old route of the Sienese Cassia. After this *submansio*, the road heads north taking a forced and narrow, but easily passable, way through the Ombrone valley, crossing it from south to north and reaching the bridge of Buonconvento (known from written sources starting with the 9th century). From here it went back, closely following the Roman road-network across the whole valley, to reach *Arbia* (Ponte d'Arbia) and finally arriving in Siena (fig. 6).

	TP	Gamurrini	Lopes Pegna
Siena-Umbro fl.	8,8	31,6	21,4
Umbro fl.-ad Mensulas	23,6		15,4
Ad Mensulas-Manliana	26,6	30,5	4,9
Manliana-ad Novas	11,8		10
Ad Novas-Chiusi	13,3	12,8	12,8

Tab. 1. Distances in the interpretations of the authors (expressed in Km).

	Gamurrini	Lopes Pegna
Siena-Umbro fl.	-2,5%	143%
Umbro fl.-ad Mensulas		-34,7%
Ad Mensulas-Manliana	-20,6%	-81,5%
Manliana-ad Novas		15,3%
Ad Novas-Chiusi	-4%	-4%

Tab. 2. Percentage errors of distances (the calculation is: observed value/expected value).

	Gamurrini	Lopes Pegna
Siena-Umbro fl.	-2,5%	-9,3%
Umbro fl.-ad Mensulas		75%
Ad Mensulas-Manliana	-20,6%	-81,5%
Manliana-ad Novas		15,3%
Ad Novas-Chiusi	-4%	-4%

Tab. 3. Percentage errors of distances with Siena-Umbro Fl. and Umbro Fl.-ad Mensulas interpolated.

4.2. The settlement network

Having postulated the existence, between Val d'Orcia and Val d'Arbia, of a tract of *cursus publicus* that linked Chiusi to Siena, which later turns into the main route of the Via Francigena, we now propose a diachronic reading of the articulation regarding the settlement network of these valleys.

The 1st century AD looks like an initial moment of consolidation within the economic and politic system imposed by the foundation, dated to the early years of the previous century, of the towns of Chiusi and Siena, at the borders of the geographical area which is here being considered. In the first quarter of the 2nd century we witness the constitution of an element that will represent a new outstanding commercial engine: the road-network between the two cities. Such an enterprise involved also the creation of some infrastructures to serve the road system, such as bridges and rest places: this is probably the case of The Pontaccio, which in its current form should be connected to a *diverticulum* of the

Francigena passing by the Church of Cosona and taking to Pienza. A consideration has to be made on the sites interpreted as dispersed settlement (single or small groups of houses, farms); 37.64% of them is less than 2 km away from the road, 15.29% are located between 2 and 4 km, 16.47% between 4 and 6 km, while the remaining 30.6%, is more than 6 km away (fig. 7). During this century, only 16 settlements of this kind were founded, starting a downward trend that will reverse only with the 4th century.

If we place the settlements in a hierarchy depending on the assumed size and apply the geographical pattern of the rank-size rule, for the 1st century AD the results show four well-defined trends. First of all there are Siena and Chiusi, placed at the top of the hierarchical scale and forming a curve above the first part of the ideal trend. This circumstance is known and well explained; it occurs when there are two or more similar settlements within a sampled geographical area, without having one prevailing over the other.

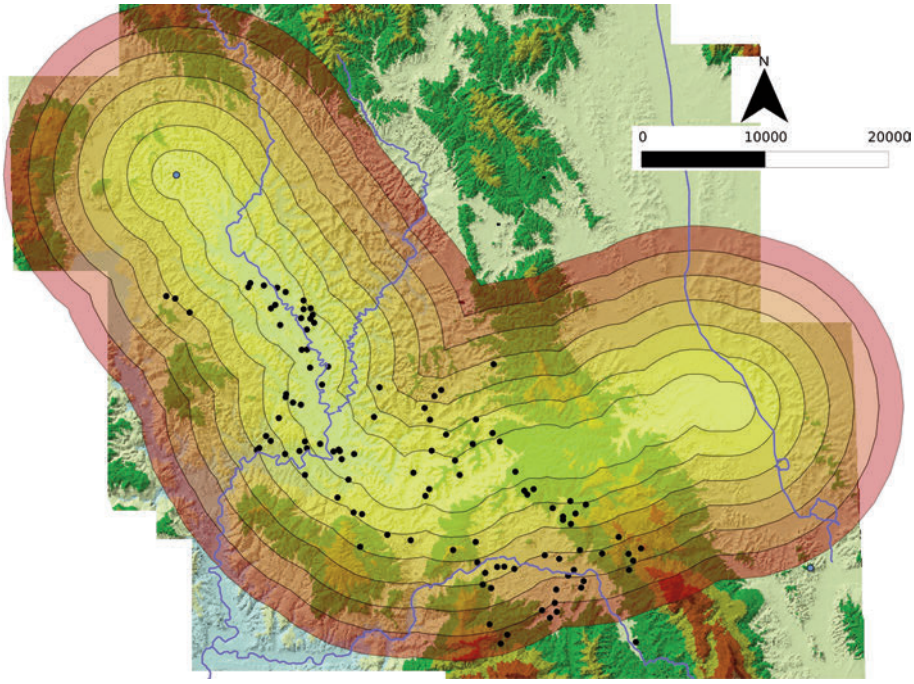

Fig. 7. Buffer zone analysis: relations between road and settlements (1st century).

The second group is the one determined by the curve of large settlements (in number of 3), remaining far from the ideal line (between -30% and -15%). It has to be underlined that among the minor in size of the large settlements and the biggest of the smaller ones we have a significant gap (with a deviation from the ideal curve of -15% to about -73%). This indicates that there is a substantial difference between the secondary centers and other smaller settlements, which will become even more pronounced in later centuries.

The third group is formed by the settlements hierarchically subsequent to the fifth site in the classification; the curve is stabilized, moving parallel to the ideal one (with a distance always comprised between 72% and 82%). Despite the distance from the expected curve, the set shows a constant regularity of the regression and a coherent distribution of medium-small settlements in the area.

The last group, with an error of 83%-98% from the expected curve, is made up by the smaller settlements. This divergence increases with the rank: the reason for such a rapid decrease in the magnitude of the settlements (which, incidentally, is a tendency observed in all the analyzed periods, even in the 21st century which has been used as a term of comparison) can be due either to an actual trend of the settlement system which declines rapidly downwards in size, or to an error of evaluation in estimating the magnitude of small settlements.

The 2nd century AD in some respects follows the previous one. The sites existing at this stage are 84 (they were 110 in the previous century, with a decrease of 23.3%), divided between centralized settlement (21) and dispersed settlement (63). Among them there are 9 *villas*, 3 *villas*/settlements, 7 settlements, 1 village, 56 houses, 1 *mansio*, 7 farms. The abandoned sites increase considerably, passing from the 29 of the previous century to 49.

The 3rd century represents a time of deep shifts in the settlement network. As in the previous century, there are two new foundations (dispersed houses), but the settlement system seems much less structured. The abandonments during this period are five, but if we take into account the sites deserted within the end of the previous century (and therefore not existing anymore in the 3rd century), they become 49, of which 39 are defined as houses or farms. The total number of settlements is 39, more than 50% less than in the previous period. It's the endpoint of a negative trend starting with the 1st century BC, which will start to reverse only between the 4th and the 6th century AD. The *villas* that are still occupied pass from the 9 of the previous century to 3, the dispersed houses from 56 to 21, farms from 7 to 4: these are the cat-

egories that show clear signs of a crisis, opposed to centralized forms of settlement that do not show evidence of failure (the number of sites remains constant between the 2nd and the 3rd century for *villas*/settlements, settlements, villages, *mansiones*). The rank-size rule shows also other features of the network. A substantial change in the pattern is given by the fourth settlement in the hierarchy, which has a much lower size than that of the previous century (5600 m^2 against 21000 m^2). This data shows us the beginning of a peculiar trait of the settlement network, destined to endure and even to worsen in the following centuries: the absence of intermediate realities between cities and small settlements. The determined curve can be split into 4 groups: cities, big settlements, medium settlements (which, despite the distance from the ideal curve, follows its trend) and small ones (which gradually diverge more and more from the expected values).

As before, the next step in our analysis has been to look at the distance from the assumed road network. Among the settlements of the 3rd century more than 40% is less than 2 km away; if we consider also the sites that are within 4 km we will reach almost 50% of the total number. The settlements that are abandoned in this period are evenly distributed in the first three distance bands (27% within 0-2 km, 29% within 2-4 km, 23% within 4-6 km), showing no significant trends. But the remarkable fact is that the dispersed settlements are, in 56% of all cases, within walking distance (between 0 and 2 km) from the assumed road-network. In the previous century, the dispersed houses and farms in the same range were only 34% with the remaining 66% divided in an almost homogeneous distribution between 2 and 14 km.

If the 3rd century AD is characterized, in rural areas, by a crisis in the dispersed settlement and a scarcity of *villas,* the 4th century should be read as an attempt to find a new economic and social balance. The dispersed settlement grows for the first time after two centuries of negative trend (from 26 sites in the 3rd century to 34 in the 4th century). The sites without a continuity of occupation are 5 (in the transition between the 2nd and the 3rd century we had 49 abandoned sites) and the R-index of the distribution based on the nearest-neighbor analysis grows, passing in aggregation even the levels of the 2nd century[14]. The rank-size rule describing the 4th century faithfully reproduces the one of the 3rd century until the tenth element of the list. From here on it runs basically parallel to the ideal

[14] The R-index is 0.646662154 in the 1st century BC, 0.654670124 in the 1st century AD, 0.611855154 in the 2nd century AD, 0,.582271484 in the 3rd century AD, 0.620291234in the 4th century AD.

curve, opposed to that of the 3rd century, which quickly decays. After three centuries of constant decrease of inhabited areas, for the first time the curves cross, showing an expansion of the settlement network.

The percentage ratio between small dispersed settlement and medium-sized secondary settlement increases continuously in favor of the latter from the 1st to the 4th century AD, reaching 69.38% compared to an initial 30.62%. These types of sites, in terms of size, capability to attract population, labor force and economy, have to be opposed to the dispersed settlement system which characterized this part of the country in the early centuries of the Roman Empire. In fact, it is this new settlement pattern made of centralized sites that will be qualified as a winner over other solutions.

Going on to the 5th century, we record a different progress. For the first time since the 1st century BC, the settlement shows conflicting trends: the dispersed settlement has a slight increase, while 5 of the 15 bigger settlements existing during the previous century are abandoned. This is even more pronounced in the rank-size rule, which returns a highly marked distinction between towns and rural settlements. Anyway, the heavy deviation from the expected to the observed values does not prevent to intercept the curve of the 3rd century in correspondence of the smaller settlements, a fact we had already observed in the previous century. As a matter of fact, with the 5th century, all the last surviving settlements dating back to the 1st century BC are definitively abandoned. What is even more remarkable about this period is that none of the settlements founded between the 1st century BC and in the 3rd century AD (over 100 sites) has a continuity of occupation.

If at this stage we can still speak of a society going through a crisis, the events taking place in Italy during the next century in Italy, with the Gothic War and the Lombard conquest, will be the driving factor behind a substantially new early medieval settlement network. We are not facing a simple regression, but rather a de-structured society, in which the elements of discontinuity will produce a completely different social reality. Compared to the 5th century, we observe almost a halving of the settlements. The large number of new foundations (18) occurring during the 6th century cannot stand the shock given by sites that do not live past the 5th century (31). Once again, the trend is underlined and exacerbated by secondary settlements, which from the 4th to the 6th century drop in number from 15 to 5. The few surviving ones are not comparable with those of the previous centuries: the third settlement in the rank-size rule (i.e. the biggest rural center) measures 2200 m^2, while the expected measurement is 38333 m^2. Data is even more significant if we consid-

er that the corresponding site measured 4700 m^2 in the previous century and 29,000 m^2 in the 4th century. The result is a deep gap in settlement regression between the urban sites and the large rural centers; despite a physiological distance from the ideal curve, in the second part of the graph (sites with lower magnitude), the rhythm is stabilized and the regression falls within normal parameters.

The attractive power of the road network, which is evident during the previous periods, now loses its effectiveness: only 25% of the existing sites is located less than 2 km away from the road. This data has not to be read as a consequence of the physical disappearance of the infrastructure: it is illogical to assume that a work of highest importance, as can be a road, which for centuries has influenced the settlement network and the economy of a geographical area and that will return, at least in part, a little later to perform its function, may disappear in such a short period. However, what actually comes to an end is the economic system that had been at least partly originated by the presence of the *diverticulum* from Siena to Chiusi. We could go even further and, reversing the original trend, imagine a centrifugal force exercised by the road during this period. Considering that the century is marked by wars and invasions, naturally progressing along the arteries of the Roman period, a cautious withdrawal of the settlement from the proximity of the roads could have been willingly done. Anyway, the data we have have observed can be compared with those proposed for the settlements in the dioceses of Populonia, Roselle and Sovana (Citter, Patacchini, Valdambrini 2012, pp. 94-96), where the attractiveness of the road remains marked during the 5th and the 6th century while it drops significantly between the 8th and 9th century, and then again between the 10th and the 11th century. The breaking point, placed by the authors during the 10th century, is related to the formation of a castle network, which seems to be an economic system less influenced by the ancient road system.

If the evidence of Lombard rural settlement can be difficult to trace down, the presence and the importance assigned by Lombard elites to agrestic areas: the numerous royal and aristocratic foundations of monasteries, parishes and churches, which are documented by written sources starting with the 7th century, leave no doubt about it. Besides the important clues on evangelization of late antique and early medieval countrysides, these sites provide also important hints for the reconstruction of settlement patterns. It is logical, in the case of monasteries, to suppose the presence of a vital group of monks shaping the agricultural and economic traits of the surrounding territory. At the same time, the building of rural parish churches implies the existence of a com-

munity that has initially to be christianized; after that, it had to be taken care of in its pastoral and spiritual needs. This implies that there must have been, if not exactly a village-type settlement insisting immediately close to the church, at least a dispersed population to be recognized in the topographic basin of the religious structure.

The 7th century is a period in which the roman settlement system is permanently loosened and the formation of medieval landscapes slowly starts to take form; this last process will continue until the 10th century, expressing itself through a variety of economic structures and settlements such as villages, generic settlements, *casali*, castles and *curtes*. In fact, on the threshold of the 8th century, the rural settlement was mainly structured on centralized agglomerations whose primary economic basis was agriculture. The dispersed settlement suffers a decrease, passing from over 80% of the previous century to 75%. The relationship between roads and settlements in the 7th century is completely loose: 50% of the known sites appear to be more than 6 km away from the Roman roads; at the same time, the attractive force of the emerging Via Francigena starts to be seemingly effective: the distance from the road system, considering all kind of settlements, appears to be less than 8 km.

From the beginning of the 8th century we are finally moving towards an initial definitive structuring of settlement patterns and power markers, with excavated rural sites showing a tendency towards the formation of centers controlling the means of production. The new foundations, in all cases to be classified as secondary settlement, are now defined with terms such as generic settlement, village, castle and *casalis*; moreover we have 11 religious buildings documented in the testimonial source dating to AD 715. We are therefore witnessing a reversal of the dispersed/centralized settlement ratio. Single houses disappear completely, a figure which goes in the direction of the establishment of centralized sites; such places concentrated work, production and storage or trading activities, preluding to the *curtis* system that will be the real landmark of the next century (Cammarosano 2009, p. 88; Sergi 1993, pp. 25-94). This trend characterizes the whole of Europe, and the same increase in the number of centralized places (villages) can be seen, for instance, in France (Henning 2008, pp. 45-46).

The Carolingian period is marked by a slight increase in the number of existing settlements (30), divided in one generic settlement, one village, two houses, two *casalis*, eighteen churches, three castles and three *curtes*. The *curtis* really stands out as the distinguishing feature of the period; in fact, if it is true that this economic system originates in the previous century, its moment of maximum diffusion occurs only with the 9th century.

The 10th century shows trends of growth very similar to the previous century: each site type existing during the 9th century grows in number or at least remains constant. The churches rise from 18 to 20, generic settlements from 1 to 4, castles from 3 to 5, *curtes* from 3 to 4, scattered houses remain constant (2) as do villages (1) and *casalis* (2). But there are two significant facts we have to underline. One of them concerns the relationship between centralized and dispersed settlement: the first type, after reaching the majority of sites between the 7th and the 8th century, maintains a stable relationship with the second type during the 9th century; in the 10th century, instead, the difference tends to grow and becomes even more pronounced. The second element regards the height above sea level of the settled places, since the average value of the sites during the 10th century is the highest since the 1st century BC. This fact gains still more importance if we consider that the settlements founded during the 10th century are the highest and the only ones to exceed the standard deviation calculated on the averages of the whole timespan considered by this paper (1th century BC-10th century AD). If we have a separate look at Valdorcia and Valdarbia, this trend can be seen even more in detail: during the 2nd century the sites of the Orcia valley had an average height of 402 m above the sea level, during the 8th century the value drops to 358 m and in the 10th century it raises up to 408 m; for the Arbia valley, during the 2nd century the average is 174 m above the sea level, the same as in the 8th, while in the 10th century we arrive at 196 m above the sea level.

5. Conclusions

Considering all the hypotheses we have proposed for the passage of the Sienese Cassia *diverticulum*, the element that appears to be more discriminating and that may ultimately count as conclusive is the fact that hardly any Roman plan could allow for the construction of two parallel roads just a few kilometers away from each other; this is even more evident if we consider the very likely contemporaneity of the two tracks.

Is fair to point out that at this point of the analysis is not possible to rule out with absolute certainty the other path, stopping the work to an evaluation level. unable to verify the validity.

The road system in this area, however, had to be much more complex, involving also routes external to the *cursus publicus* we have so far reconstructed. This is the case of the linking roads which from Chiusi, heading South, climbed the ridge of the hill system by La Foce and then,

through the Valdorcia, followed the course of the river between Mount Amiata and Colle di Montalcino, before turning towards the Grosseto area in order to arrive at Roselle. Similarly, it is possible to postulate the existence of a secondary road that connected Siena directly to Bolsena, and that after Torrenieri continued along the Valdorcia, passing by the Radicofani hill and across the Paglia valley. This Roman route, which probably played a secondary role in the Empire's road network, will later become the Francigena of the Middle Ages (fig. 7).

The valleys of Orcia and Arbia were two peripheral areas in Roman times, where the influences of neighboring towns was thoroughly mitigated. However, especially for the 1st and the 2nd century AD, the rural spaces appear to be heavily organized around big settlements, which were supposed to manage agricultural production. This element partly confirms the public nature of most of these areas, suggesting a partition of the territory of Chiusi among Silla's soldiers at the end of the civil war with Mario.

The first great changes occur during the 3rd century, when the crisis seems to affect especially the category of small landowners, who are often forced to sell their properties and bind themselves to a large estate. In the same period, the agricultural production is more and more based on a number of centralized poles persisting throughout the Roman period. Decrease in the amount of the major centers of agricultural production cannot be seen, but an indication of lower quality comes from the rank-size rule curve, which at this stage seems much more irregular if compared to the expected level of this period as well as to the results obtained for earlier centuries.

If the the 4th and the 5th century witness an improvement of the settlement network, the events of the Gothic War and the Lombard invasions, between the second quarter and the end of the 6th century, will mark a clear point of no return in the rural articulation of the two valleys. But the element that mostly outlines this stage, differentiating it radically from the crisis of the 3rd century, is the abandonment of the settlements we can define as *central places*; this shows not so much (or not only) an economic crisis, but a general process of social disintegration taking place during the 6th century. In the two previous centuries these sites had maintained their central role in production and trade: an example is Santa Cristina in Caius (Goggioli, Valenti 2010), where the 4th and the 5th century show the dismantling of a thermal complex, probably due to recycle and commercialization of metals and building materials.

From the 7th century on, the political and economic powers acting on the countryside undergo a very slow process that will complete itself only with the second half of the 8th-9th century and that will highlight other

types of *central places* (hilltop sites). This becomes clear by observing the average values of height above the sea level of the chosen locations, which tend to witness a peak between the 8th and the 10th century. At the same time we have an almost complete disappearance of dispersed settlements, which are mainly replaced by villages.

Another process that will take shape starting with the 7th century is the slow emergence of a new road system that will replace the Roman one; the Francigena, especially if we consider that it is the main artery of the medieval road network, will never have (if not in the 10th century and then in the late medieval period) the attraction power showed before by the Cassia *diverticulum* leading to Siena, although the latter was a secondary and peripheral track in roman times. But we have to keep in mind that the Francigena was born on completely different bases, not so much to move economy and without a well-shaped plan that originated the road and invested on it. The medieval track should be seen as a large set of roads connecting most of Christian Europe to Rome; therefore, it cannot be intended as a unitarian infrastructure designed and built to emulate the great ancient roads.

The artificial system formed between 1st and 10th centuries in Valdorcia and Valdarbia is subjected to changes, generated by several variables, one of which is the road system, thus forming a dynamic system.

To summarize we need to make some concluding remarks on the methodological experience of the work we are presenting, with a particular reference to the use of decision-making techniques. The GIS tools for route calculation, applied in many other investigationd, are a methodology still far from being fully understood and digested by the scientific community that deals with historical subjects. The main problem in applying these means can be resumed in a sort of rebelliousness of the software; or, rather, in an inability of the researchers mind to gain full understanding of all the dynamics that make up the net of ancient landscapes, which have be to be translated into variables and processed by the computer.

More than in other archaeological researches, by adopting such an approach we realize that our discipline is still heavily based on the concept of empiricism, with no negative meaning.

From this point of view, computer simulations and reconstructions can offer us not much a metaphysical truth about what we dig, but the reproducibility of the experiment and a variety of probabilistic results. The success of these methodologies, in the wake of 19th century positivist thought and following the *New Archaeology* tradition originated in the 1960s, can help us to shape more solid historical models, supported by large amounts of data linked together in a logical manner.

References

F. Annunziata, M. Coni, F. Pinna, F. Maltinti, S. Portas 2004, *Progettazione stradale integrata*, Bologna.

F. Annunziata, F. Cerere, M. Coni 2007, *Progettazione stradale. Dalla ricerca al disegno delle strade*, Palermo.

F. Auerbach 1913, *Das Gesetz der Bevölkerungskonzentration*, "Petermann's Geographische Mitteilungen", 59, pp. 73-76.

A. Levi, M. Levi 1978, *La* Tabula Peutingeriana, Bologna.

F. Cambi, N. Terrenato 1994, *Introduzione all'archeologia dei paesaggi*, Roma.

P. Cammarosano 2009, *Nobili e re. L'Italia politica nell'alto medioevo*, Bari.

P. Cammarosano, V. Passeri 1976, *I castelli nel senese,* Vol. II, Siena.

C. Citter, A. Patacchini, G. Valdambrini 2012, *Necropoli, insediamenti e viabilità nell'Europa tardo e post romana (AD 400-800): l'area franco-alamanna e l'area anglosassone a confronto*, in C. Ebanista, M. Rotili (eds), *Le trasformazioni del mondo romano e le grandi migrazioni: nuovi popoli dall'Europa settentrionale e centro-orientale alle coste del Mediterraneo*, Atti del Convegno Internazionale di Studi (Cimitile-Santa Maria Capua Vetere, 16-17 giugno 2011), Cimitile, pp. 89-104.

D.L. Clarke 1968, *Archeologia analitica*, ed. It., Venezia 1998.

C. Corsi 2000, *Le strutture di servizio del* Cursus Publicus *in Italia*, Oxford.

R. Farinelli, F. Olivelli 2009, *La* rank size rule *e il popolamento medievale in Toscana meridionale*, in G. Macchi (ed), *Geografie del popolamento: casi di studio, metodi e teorie*, Atti della Giornata di Studi (Grosseto, 24-26 settembre 2008), Siena.

G.F. Gamurrini 1898, *Ricognizione delle* mansiones ad Novas, ad Statuas, ad Graecos *lungo la via Cassia da Chiusi a Firenze*, "Notizie degli Scavi di Antichità", 1898, pp. 271-276.

R. Gietl, M. Doneus, M. Fera 2008, *Cost Distance Analysis in an Alpine environment: comparison of different cost surface modules*, in A. Posluschny, K. Lambers (eds), *Layers of perception* (CAA 2007), Bonn, pp. 342-350.

S. Goggioli, M. Valenti 2010, *Buonconvento (SI). Santa Cristina in Caio: indagini 2010*, "Notiziario della Soprintendenza per i beni archeologici della Toscana", 6, pp. 31-48.

A. Guidi 1985, *An application of the Rank-Size rule to protohistoric settlements in the Middle Tyrrhenian area*, in C. Malone, S. Stoddart (eds), *Papers in Italian Archaeology, IV. The Cambridge Conference. Part III; Patterns in Protohistory*, Oxford, pp. 217-242.

J. Henning 2008, *Strong rulers – weak economy? Rome, the Carolingians and the archeology of the slavery in the first millennium AD*, in J.R. Davis, M. McCormick (eds), *The long morning of medieval Europe*, Aldershot, pp. 33-53.

I. Hodder, C. Orton 1976, *Spatial analysis in archaeology*, Cambridge.

G.A. Johnson 1978, *Spatial organization of Early Uruk system*, in *Colloques Internationaux du centre national de la recherche scientifique "L'Archéologie de l'Iraq du début de l'époque néolithique a 333 avant notre ère*, Paris, 204-263.

G.A. Johnson 1980a, *Monitoring complex system integration and boundary phenomena with settlement size data*, in S.E. Van der Leuwe (ed), *Archaeological approaches to the study of complexity,* Amsterdam, pp. 144-188.

G.A. Johnson 1980b, *Rank-size convexity and system integration: a view from archaeology*, "Economic Geography", 56, pp. 234-247.

M. Lopes Pegna 1953, *Itinera Etruria*, "Studi Etruschi", XXII, 1952-1953, pp. 381-410.

J. Lu, G. Zhang, D. Ruan, F. Wu 2007, *Multi-objective group decision making – methods, software and applications with fuzzy set techniques*, London.

G. Macchi 2009, *Spazio e misura*, Siena.

S. Mambrini, R. Stopani 1989, *Insediamenti e viabilità tra val d'Orcia e val di Paglia nel medioevo*, in M. Ascheri, W. Kurze (eds), *L'Amiata nel medioevo*, Atti del Convegno (29 maggio-1 giugno 1986), Città di Castello, pp. 301-314.

A. Maroni 2001, *Prime comunità cristiane e strade romane nei territori di Siena – Arezzo – Chiusi*, III ed., Siena.

K. Miller 1916, *Itineraria romana*, Stuttgart.

A. Mosca 2002, *Via Cassia: un sistema stradale romano tra Roma e Firenze*, Firenze.

S. Patitucci Uggeri 2009, *La viabilità tra Siena e la Via Cassia nella* tabula Peutingeriana, in C. Marangio, G. Laudizi (eds), *Studi di topografia antica in onore di Giovanni Uggeri*, Galatina, pp. 371-380.

L. Quilici, S. Quilici Gigli 2003, *Carta archeologica della Valle del Sinni*, Fascicolo I, Roma.

G. Radke 1981, *Viae publicae romanae*, tr. it., Bologna.

G. Volpe 1996, *Contadini, pastori e mercanti nell'Apulia tardoantica*, Bari.

L. Von Bertalanffy 1968, *General system theory: essays on its foundation and development*, New York.