

Statistical Methods and Computer High Technology for the Study of Archaeological Presence in the Sabina Tiberina Area

F. Colosi, S. Espa, R. Gabrielli, U. Ricci, F. Verga

I.T.A.B.C. - C.N.R.

V. Salaria Km. 29.300, Monterotondo St. (Roma). Italy.

E-mail: colosi@milib.cnr.it

Abstract

The present work presents preliminary research results, carried out by the Institute of Applied Technology to Cultural Heritage (C.N.R.), relevant to the archaeological area of Sabina Tiberina (Rieti, Italy).

The research was carried out, by using applied statistical and information technology methods, with the purpose of achieving a Territorial Informative System (GIS), of the above-mentioned area. The district, under study, which includes the administrative boroughs of Magliano Sabina and Stimigliano, shows a vast chronological stratification, which ranges from the Prehistorical Period to the Roman Period. Anthropic presence is distinguished by the settlement models, but show regular consistency, throughout the various ages, being motivated by the immediate vicinity of the river Tiber, on important means by which cultural exchanges took place, and river transport revolved.

The work is divided into two parts. The first contains information, relative to the surveys carried out in the area, with the purpose of distinguishing and classifying the settlements of the Roman period; while in the second part, aspects of descriptive, documentary evidence are related, obtained by means of applied, informative systems, and several processes, employing spatial statistical analysis, aimed at the identification of scattered points.

The surveyed area

Since 1996, a historical, archaeological collaboration has been underway, within the framework of the strategic project, now finalised as " Beni Culturali" (Cultural Heritage), between two Institutes from the C.N.R. (National Research Council), Etruscan-Italic Archaeology and Applied Technology to Cultural Heritage. The purpose of the research is to succeed in identifying and assessing archaeological wealth, as well as reconstruction, relative to the topographical - historical context of the area, geographically recognised as relevant, to the centre of Magliano Sabina. The information is undergoing elaboration processes to accomplish a GIS, pertaining to that area.

The area undergoing research is geographically delimited, to the west and south of the Tiber river, and east of the hilly range of Colle Sala, while to the north, an approximate geographical limit is formed by the Fosso dell' Aia. The area is comprised in foglio 138, table III SO (Magliano Sabina), and in foglio 144, table IV NO (Stimigliano) (Pl. 1). In the preliminary stages, the choice was made to carry out research in the area, which lies between Fosso Campana, the river Tiber, and the L'Aia torrent. During the Roman period, the zone gravitated towards the town of Forum Novum, and was characterised by a roadway, which in ancient times connected it to the *Via Flaminia*.

The whole area appears to be morphologically homogenous, and it features wide, flat areas, delimited by hilly mounds of Plio - Pleistocene deposits, formed by uneven calcareous yellow tufa. The elevations, along the left bank of the Tiber, have a tabular and sinuous tendency, which are suitable for extensive farming. Furthermore, the remarkable accumulation of fossils is noted in the argillaceous, sandy strata, due to the phenomenal ingression and regression of the sea. The area is characterised by the presence of the river Tiber, which has always been an essential element, from both an environmental and, consequently, an historical point of

view. A series of ditches and streams form a thick, hydrographic network, which affects the whole area and whose accidental flow is determined, by the hilly tendency of the entire territory.

Historical- archaeological survey

Since archaic times, the river Tiber has been the means, by which goods could circulate, as well as being responsible for cultural exchanges. It was due to the Tiber, that cultural exchanges with the *falisco-capenate* area developed, and *falisci* cultural elements were discovered, in dwellings, along the east bank of the river¹.

The river was connected by a roadway, running east to west, probably to join the centres, situated along the left bank of the Tiber, with Falerii, already existent in archaic times; this roadway was retraced, in the Roman period, to link the municipium of *Forum Novum* with the *Via Flaminia* (QUILICI GIGLI, 1986, pp. 75-77)² (Pl.2). The *consolare Flaminia*, redirected the direction of the roadways (around which the territory revolved in archaic times), to practically follow the course of the river, at this point, crossing over the Tiber at Piana di Campitelli, on the so called "Pile d' Augusto". Slightly north of this point an important Roman settlement was discovered (III cen. B.C.-V cen. A.D.)³.

¹ Moreover, materials of the *falisca* culture, which have been sporadically discovered in the area of Colle Rosetta, are undergoing study and publication by the authors.

According to Muzzioli (1980 p. 36) the peak of the expendability period for the *falisca* area and the whole of Etruria in general, which gravitated in the Tiber valley, can be calculated within the chronological span of the fifth and fourth (V & IV) centuries B.C.

² In fact the author sustains the theory that this antique roadway dates back to a former archaic period in view of both the topography of the area and the presence of an archaic settlement of remarkable entity in the location of Colle Rosetta. For the last section of the roadway is suggested a route which "volgesse a Poggio Somlavilla, salendo le pendici di Casale Tosti".

³ However the findings relevant to that roadway only date back to the Roman period. In fact from the latter part of the 19th century, thanks to surveys carried out by Pasqui, traces from part of a paved roadway in the locality of Colle Tondo were discovered (Gamurrini *et al.* 1972, p. 347).

In fact, the area became the most suitable habitat, for the development of the villa "phenomenon", after the Romanisation phase (III cen. B.C.).

The preoccupation of settling, within the vicinity of areas suitable for agriculture, with the possibility of controlling both the internal water courses, as well as those connecting the Tiber valley (and, which had delineated settlements in archaic times), was greatly emphasised, during the Romanisation phase, and it reached its height in development, dating in the late Republican and Imperial period.

The location of the settlements, at that time, appears to be significantly connected, to the course of the river. The dwellings were denser, particularly in the areas of Magliano Sabina and Poggio Sommavilla. Due to their position on higher ground, overlooking the Tiber, they were able to exploit the thick network of secondary waterways and springs which characterise the territory.

In particular, the settlements located in the area, geographically included in the Magliano table, appear to be distributed, mainly, in the neighbouring areas of the centre. Following the decline and, therefore, the discontinuity of the site (III cen. B.C.), a different type of occupation probably began in the territory, no longer concentrated in the same centre, but rather, widespread, due to agricultural exploitation of the land. Coinciding with this change, in the method of occupation, was the historical phase of the Roman conquest, in the Sabina Tiberina area.

Methodical surveys have indicated that from the end of the Republican period, then in the mid and late Imperial period, estates, of limited extents, appeared close to large properties. The majority of the sites seem to follow the course of the hills, being situated in a north-east and south-west direction. The rustic settlements, in particular, were located, either halfway up the slopes, or on higher ground. Also, the typology of the villa, in the lower part of the valley, is present, evidence of the Ponti Novi⁴ and Colle Rampo settlements, located on the flat land by the river, as well as the above-mentioned, large villa of Campitelli. The latter, in fact, together with that of St. Sebastiano, which we will discuss in greater depth at a later stage, make up the other settlement, from which direct and indirect evidence has provided much information. An abundance of ceramics and building material are spread over a wide area, parallel to the

where numerous uprooted paving stones can be seen leaning against two farmhouses in the area. On the contrary the *ruderatio* has been conserved for a length of 5m. at foot of Colle Rosetta, which follows the course of the Rosetta stream, where numerous uprooted paving stones are visible.

A longer portion of a tuffaceous slope at Torre Grappignano, also reported by Pasqui (Gamurrini *et al.* 1972, p. 347) is at present still detectable and leads to the supposition of a thoroughfare in that area. The ancient bridge over the Fosso Casaglia however can no longer be traced, while ruins of a tower shaped sepulchral monument are still evident, near the church of Madonna del Piano, against which a farmhouse was built in more recent times (Gamurrini *et al.* 1972, p.348; Reggiani 1980, p. 11). The existence of the final stretch of roadway that reached *Forum Novum* is marked by the presence of a serious of sepulchral monuments which lined it on both sides (Reggiani 1980, pp. 7-10). Furthermore, the presence of tombs dug into the tufa have been discovered along the tuffaceous hillside visible from the main provincial Sabine road where the modern bridge over the l' Aia is situated.

⁴ Also the discovery of an epigraph gives proof of its existence (Filippi 1979, pp. 227 -228).

Flaminia⁵, and numerous blocks of tufa are accumulated near the farmhouse, where the small altar, no longer visible at the site, was found.

The asserted period for the ceramic materials, from the greater part of the villas in that area, is chronologically included, between the II cen. B.C. and the II cen. A.D., with some later findings, almost up to the IV cen. A.D. (Campitelli, Corsetti). The cases, in which such an ample chronological excursus is verified, are probably connected to the reorganisation of the establishments, which had to assume the dimensions of an authentic estate, made possible by slave labour, which increased during the Imperial period. Moreover, in the same context (in addition to the above-mentioned Campitelli and Corsetti sites, are the Madonna Grande and Poggetti sites) the antiquity of the settlements is demonstrated by the presence of squared tufa blocks, and also by the sporadic and fragmentary findings from the buildings. Architectural elements, connected to *opus reticolatum*, show subsequent extensions, by the use of *caementicium*⁶.

The territorial belt, lying south of the considered area, which geographically includes the area, between the modern centre of Stimigliano and the course of the river Tiber, shows an ancient settlement, characterised by a very thorough extension, attributed to intensive and, therefore, industrial exploitation of the land. The chronological range, where the greater numbers of villas appear (I-II D.C.), leads us to assume a qualitative occupational rise in the area, during the Imperial period. This theory is mainly connected to *Forum Novum*, established in the second half of I cen. B.C., around which many dwellings developed.

In the last twenty years, an anthropic increase has greatly influenced this territory, but has erased, to a great extent, archaeological traces, relating to the settlements. So, bearing this in mind, the documentation, furnished by the St. Sebastiano site, appears to be most precious .

The settlement rose in a strategic position, as regards the network of roads in the area. Since the latter part of the 19th century, information has been recorded on the roadway, in the proximity of the villa, which linked the municipium of Forum Novum with the area of Fosso Campana (Pl. 2). This partially retraces an archaic track, which wound around the ancient hamlet of Foglia, following an east to west direction, as mentioned above.

The villa was situated to the east of the Tiber, on a hill top, which was characterised by a network of rustic settlements, varying in size and entity. To be more precise, it developed

⁵ In particular the rims from Greek - Italic amphorae have been found, also a black painted rim Morel 2621 (285 B.C. circa), other fragments of ceramics *sigillata Italica* and *Africana*, which include the shapes Hayes 8 (II century A.D.) and Hayes 61 (IV-V century A.D.). An abundance of ceramics commonly used for eating and cooking have also been found together with numerous fragments of roof tiles, two of which show seals.

⁶ More consistent elements on the subject may be deduced from the Corsetti site where squared building blocks still *in situ* have been identified, also visible is a level section of flooring which flanks the modern roadway as well as the presence of a large concrete tank built in four arches. These essential findings allow for the progression of various building phases to be observed from the end of the Republican period to the Imperial age.

along the plateau, situated halfway between the hilly slopes and elevations, extending for one hectare (Pl. 3). In the 1970s, following deep agricultural excavations, it was, in fact, possible to identify, if only partially, structures relating to the villa (Pl. 4); the presence of numerous *cubilia*, which were brought to light on the same occasion, gave rise to the hypothesis that this settlement had also had an earlier phase, with *opus reticolatum*. The apparent chronological differences, between the materials and the structures, can be resolved in terms of a delay in architectonic forms, as demonstrated in other cases, outside Rome.

Housed in the Civic Museum of Magliano Sabina, are the materials from the settlement, which are fundamental for research purposes, as far as function and entity are concerned.

The prevailing presence of household crockery and food containers indicate an eminent farming establishment. The amphorae, in particular, greatly imply a typology of the *Dressel 2/4* shape, used in ancient times, to transport and store wine. The basins and jugs seem to be represented by more commonly shaped ceramics. Included in the household equipment is a large grinding machine, made of lava stone, and the terracotta weights for a loom. These objects clearly point out textile activity and the production of flour: connected to the daily of farming and storage, are iron tools (two double-sided axes and a chisel).

Numerous fragments, from vitreous phials and unguent containers to a bronze fibula (AUCISSA type – Nord Italica production), indicate other household items.

A remarkable quantity of ceramics, *Sigillata Italica*, are represented in a wide variety of shapes, mainly dating back to the first half of the 1st century, B.C. (Pl. 5). The items are plates, goblets, and most of all, hemispheric bowls, with inscriptions on the base, and graffiti portraying invitations to a banquet.

Fragments of ceramics, *Sigillata Africana*, are rather scarce; among these are plates and bowls, dating from II cen. A.D. to III cen. A.D.

Numerous vitreous elements, relevant to windows, fragments of coloured plaster, and various types of marble classify the settlement as a prestigious dwelling place.

The presence of materials, connected to the preservation of food-stuffs, for domestic and also private use, enables this settlement to be related to the model provided by sources⁷, and, already, it has been repeatedly acknowledged in the territory as a villa, articulated in a *pars fructuaria* (intended for farming and the preservation of food-stuffs), a *pars rustica* (intended for labourers' housing), and, a *pars urbana*, (intended for the residence of the owner of the estate).

The Informative System

Regarding the research carried out in the area, defined by sources as Sabina Tiberina, the G.I.S. was developed, by first entering the basic maps of the area into the cartographic data

base. To be more precise, seven tables in 1:25.000 scale of the I.G.M. were digitised in raster format, for topographical reference on video, while the infrastructure and the main hydrography present in the interested areas were digitised, to establish a topographical reference for the printing of thematic maps. Subsequently, the numeric orography, in 1:25.000 scale of the I.G.M. and also the aerial coverage of the Magliano Sabina district, using the same scale, was input. Furthermore, an image from the orbiting station, LANDSAT, of the whole "Sabina Tiberina" area, as well as the regional geology in 1:100.000 scale, was geo-referenced and entered into GIS.

Geometric and descriptive data were then inserted into the Informative System, relative to the Passo Corese (Ager Eretanus) I.G.M. table, assumed from the literature (Ogilvie 1965), that is to say, regarding Eretum, more than 100 archaic Sabine and Roman sites have been studied and classified. The first collection of data was obtained, by constructing codified tables, divided into period and site typology categories (*Espa, et al., 1995*).

Historical and geological data, relevant to Magliano Sabina, was acquired, by means of surveys and geo-references of the land. Furthermore, the data base of the informative system was extended, due to the detailed survey of the St. Sebastian site (see par. 2). Its importance, together with the information it supplied is described in the paragraph above.

Thus organised the GIS. was able to elaborate a whole series of data, regarding the archaeological sub-areas, of the Sabina Tiberina district. In particular, thematic maps were produced (D.T.M. reconstruction of the terrain, gradient maps (Pl. 6), the study of the positions (Pl. 7), etc.), with overlapping themes, as well as preliminary statistical analyses, in view of the modelling study of the archaeological area, which was the purpose of this research.

Spatial statistical analysis

Following a classification of period and a site typology, the first operation carried out was that of transforming the spatial arrangement of the sites, according to their historical period, (scattered points) (Fig. 1).

Preliminary analysis was then carried out, on the obtained, scattered points.

The most suitable means to identify such maps, or rather to comprehend which strains (attracting or inhibiting) have produced the observed configuration, is Ripley's K(d) function (Ripley, 1977) which is:

$$\hat{K}(d) = A \sum_{i=1}^N \sum_{j=1}^N K_{ij}(d) / N^2$$

⁷ Col. I.6

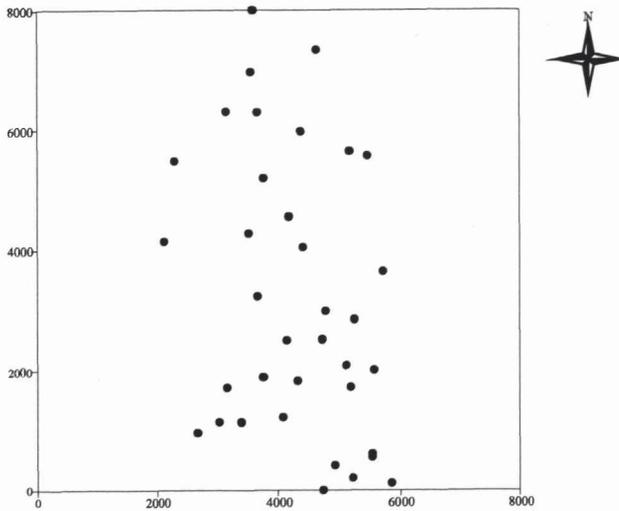


Fig. 1. Map of the points, relating to the Roman sites in the studied area

In the application shown, a transformed function, $\hat{L}(d)$ by Besag (Besag, 1977), was preferred:

$$\hat{L}(d) = [\hat{K}(d)\pi]^{1/2}$$

which had, moreover, the characteristic of aligning the graph, and the following results were obtained:

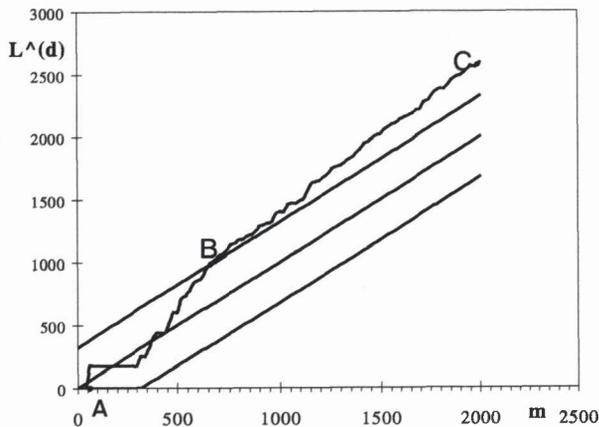


Fig. 2. Function diagram of $\hat{L}(d)$ calculated with $N=36$.

Analysing Fig. 2, it is possible to observe that :

1. The graph $\hat{L}(d)$ shows a strong clustering tendency in the interval $660 \text{ m} < d < 1940$.
2. $\hat{L}(d) = 0$ in the interval $0 < d < 60$, indicates that no sites are within a 60m radius from the centre in any of those considered (distance from the nearest neighbour)
3. $d = 660\text{m}$ is the threshold beyond which clustering is statistically significant

4. $d = 1940\text{m}$ is the threshold of maximum clustering

All this information is of extreme importance, as it establishes influential descriptive elements of the map, under observation. In the preliminary stages, at least, this allows for comparisons of space and time, for the various spatial arrangements, and moreover, forms the base, on which to construct plausible models.

Moreover, another transformation of Ripley's function was employed, or rather $\hat{L}_i(d)$ (Getis and Franklin, 1986)

$$\hat{L}_i(d) = \left[A \sum_{j=1}^n K_{ij} / \pi(n-1) \right]^{1/2}$$

thus achieving contour plots in grey tones, which indicated the areas of varying site intensity.

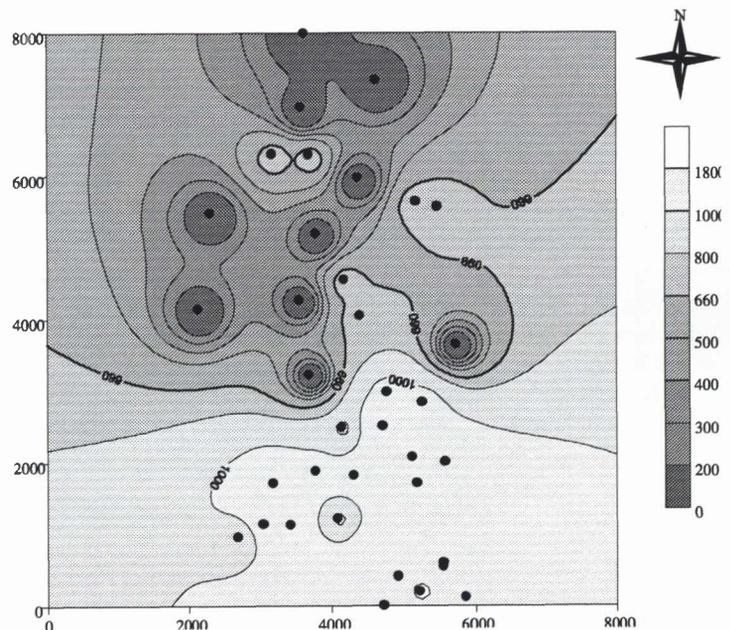


Fig. 3. Representation of $\hat{L}_i(d)$ in grey colours. The lighter sections correspond to the areas of intensive, phenomenal clustering.

Information of this nature is of fundamental importance, as it allows clustering phenomena to be quantified, at different levels of the scale.

In brief, the difference between $\hat{L}(d)$ and $\hat{L}_i(d)$ is that the first represents a mean value, while the second is calculated by an algorithm.

For instance, taking into consideration threshold $d = 660 \text{ m}$ (the distance from which the clustering becomes statistically significant), these values were calculated

$$\hat{L}_i(d) (d = 660) \quad i = 1, 2, \dots, 36$$

Fig. 3 relates the sites under study and the contours, which $\hat{L}_i(d)$ is greater than the expected value in the hypothesis of total chance, and underlines, more precisely, the areas of greater intensity in the archaeological sites.

This work has shown an example, which creates a sort of "instamatic photograph of a threshold, equal to 660 m. An interesting guideline for the study group would be to evaluate which changes are necessary, when threshold d is changed (possibly by choosing a limited number of particularly significant d levels). It would be particularly interesting to evaluate if individual clusters, at a certain resolution level, would stay the same, when the scale is varied, or if they would establish wider clusters.

Concluding considerations

The present research is divided into two explicit parts, that of historical archaeology, regarding the survey and classification of various elements, and the part concerning the application of GIS and statistical data processing. Both are incorporated into a distinctive framework, whose main purpose is to determine and safeguard cultural heritage.

In fact, in an area similar to that being examined, which is characterised by remarkable anthropic traces, the approach of competent experts, combined with various techniques, applied to territorial problems, has brought satisfying results. In other words, the localisation and classification of archaeological sites in the Magliano Sabina area, besides furnishing a Territorial Informative System, has allowed for some characteristics, concerning the position of the mentioned sites, to be studied. Analyses were also carried out, to determine how attracting or inhibiting strains behave on the examined configuration, and to what extent they range.

Moreover, the distance where the separation process, for the distribution of chance objects, begins and the distance where this process becomes statistically significant were able to be observed. Other parameters were also observed, providing a considerable amount of information, which allows, from a theoretical point of view, the possibility of spatial comparison, between various historical site configurations. These also establish a base, upon which to construct and verify descriptive models, for instance, Poisson's clustering process, which incorporates an explicit form of spatial accumulation. When adapted to the data and by estimating the parameters, this model could provide further useful information, regarding the spatial configuration under study, as, for example, the number of clusters present in the considered area, and the internal dispersion of each single cluster. The research group is at present at an advanced stage in studying these problems.

In conclusion, the aim of demonstrating the utility of combining an Informative System and statistical methods, within the research of a historical, archaeological framework, was achieved with satisfaction. Following an additional statistical analysis of the stored data and graphic representations, further information, which has established a number of important parameters, has been supplied to the GIS archives, for subsequent processing.

References

- BESAG J. (1977), "Contribution to the discussion of Dr. Ripley's paper", *Journal of the Royal Statistical Society*, B, pp. 193-195.
- ESPA G., ESPA S., GABRIELLI R., PIFFERI A., RICCI U. (1995), "Impiego integrato di metodi statistico-spaziali e tecniche informatiche nell'analisi di aree di interesse storico-archeologico", *Archeologia e calcolatori*, 6, pp. 35-60.
- FILIPPI G. (1979), "Regio IV. Sabina et Samnium. Forum Novum", *Supplementa Italica*, n.s. 5, Quasar, Roma, pp. 145-234.
- FIRMANI M. (1979), "Ricerche nella Sabina velina e tiberina", *Quaderni di Archeologia Etrusco-Italica*, 2, pp. 116-119.
- GAMURRINI G. F., COZZA A., PASQUI A., MENGARELLI R. (1972), "Carta archeologica d'Italia (1881-1897). Materiali per l'Etruria e la Sabina", *Forma Italiae*, II,1, Olschki ed, Firenze.
- GETIS A., FRANKLIN J. (1986), "Second-Order Neighborhood Analysis of Mapped Point Patterns", *Ecology*, 65 (3), pp. 473-477.
- MUZZIOLI M. P. (1980), "Cures Sabini", *Formae Italiae*, IV, 2, Olschki ed., Firenze.
- OGILVIE R.M. (1965), "Eretum", *Papers of the British School at Rome*, 32, pp. 70-112.
- QUILICI GIGLI S. (1986), "Scali e traghetti sul Tevere in epoca arcaica", *Quaderni di Archeologia Etrusco-Italica*, 12, pp. 71-89.
- REGGIANI A. M. (1980), "Monumenti funerari a torre della Sabina", *Bollettino d'Arte*, 65, pp. 7-32.
- RIPLEY B.D. (1977), "Modelling Spatial Pattern (with discussion)", *Journal of the Royal Statistical Society*, B, 39, pp. 172-212.
- SANTORO P. (1988), "Magliano Sabina: una lettura diacronica del territorio sulla base dei materiali del Museo Civico", *Quaderni di Archeologia Etrusco-Italica*, 9, pp. 335-343.
- SANTORO P. (1997), "Magliano: origini e sviluppo dell'insediamento", *Quaderni del Museo Archeologico di Magliano Sabina*, 2, Roma, pp. 79-85.

List of Figures in CD-ROM.

- Plate 1.** Magliano Sabina. Topographic map of the surveyed area. The red points represent the Roman site; The green point corresponds to the imperial villa of St. Sebastiano
- Plate 2.** Detail of Pasqui's map, pertinent to the Stimigliano area. The broken line shows the supposed Roman roadway to Forum Novum.
- Plate 3.** View of the St. Sebastiano site.
- Plate 4.** St. Sebastiano. Traces of structures relating to the villa.
- Plate 5.** Ceramics Sigillata Italica from the St. Sebastiano site.
- Plate 6.** Magliano Sabina. Gradient map overlapping archaeological sites.
Green colour: 0,5%
Brown colour: 6-10%
- Table 7.** Magliano Sabina. Map of the hillside exposures, overlapping archaeological sites.
Yellow colour: W45° exposure
Green colour: E45° exposure