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A GIS investigation of site location and landscape relationships in the Albegna Valley, Tuscany

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16.1 Introduction

The Albegna Valley/Ager Cosanus Survey started work in southern Tuscany in 1979 following on from the excavation of the villa at Settefinestre (Carandini 1985b). The survey has systematically sampled over 275 km^2 of the Ager Cosanus and the Albegna Valley (Figure 16.1). The detailed publication of the survey work is now in press but various interim reports and associated studies have already appeared in print (Attolini *et al.* 1982; Cambi *et al.* 1991; Cambi & Fentress 1988; Carandini 1985a; Celuzza & Regoli 1982). This paper will concentrate upon the analysis of the settlement pattern in the Etruscan period, and in particular the relationships between settlement location and landscape.

16.2 Landscape and settlement

Site location may be viewed in two fundamental ways: from the viewpoint of an individual site in the landscape or from the viewpoint of the landscape which is partially occupied by sites. The first approach is characterised by site catchment analysis (*e.g.,* Vita-Finzi & Higgs 1970) where all the territory within a certain distance (often taken as the distance of a one hour walk) of a settlement site is considered as conditioning the subsistence strategy and economy of the settlement site. Land within this territory is classified according to its suitability for pasture, arable purposes or wasteland and the proportions of each class of land is used to determine likely subsistence strategies of the occupants of the sites (Dennell 1987, pp. 73–5). The technique has its critics, the major drawbacks are potential change in the natural environment since antiquity, the indirect relationship between land area and the economic importance of a particular land use, its ignorance of non-economic factors and the fact that it considers the site catchment area in isolation from the rest of the landscape and indeed the world (*e.g.,* Gaffney *et al.* 1985; Hodder & Orton 1976, pp. 229–36). Despite these criticisms the technique has achieved some popularity in the analysis of field survey results, particularly among prehistorians of Italy (*e.g.,* Barker 1972, 1985; Malone & Stoddart 1994, pp. 81–93). The technique has been applied by these scholars because none of the drawbacks listed above are held to have been important in simple farming systems without complex land tenure (Malone & Stoddart 1994, pp. 81–93). Attempts have been made to elaborate the technique to incorporate social as well as economic factors by employing site catchment techniques within the context of a settlement hierarchy (Gent & Dean 1986). However, the technique seems to be inappropriate in this context because this study does concern complex agricultural and economic systems. Furthermore, this study concerns a complex society capable of manipulating its own natural environment, and one which was in contact with other regions of the Mediterranean. A final reason that site catchment analysis was not employed is that this study concerns a settlement system as a whole, and not individual settlements.

This point introduces the alternative view of the settlement pattern as a landscape inhabited by archaeological sites. In this approach the settlements are considered with reference to the entire landscape with the purpose of generalising about the locations of sites. This is achieved by considering the distribution of sites within the landscape in relation to the distribution of other elements of the landscape. Thus a more general landscape analysis is performed and the locations of archaeological sites are considered with reference to that landscape (Kvamme 1992, p. 127). Economic, and perhaps social interpretations may then be developed from an understanding of which parts of a landscape were occupied by a settlement pattern. This approach, favoured in environmental studies, is now becoming more common, particularly with the development of computer based Geographical Information Systems (GIS) capable of handling large spatially referenced data sets (Burrough 1986; Cliff & Ord 1981). A recent archaeological application of this approach has illuminated the Greek conquest of the island of Hvar in Croatia (Gaffney & Stančič 1992) and another, Hohokam agricultural systems (Kvamme 1992).

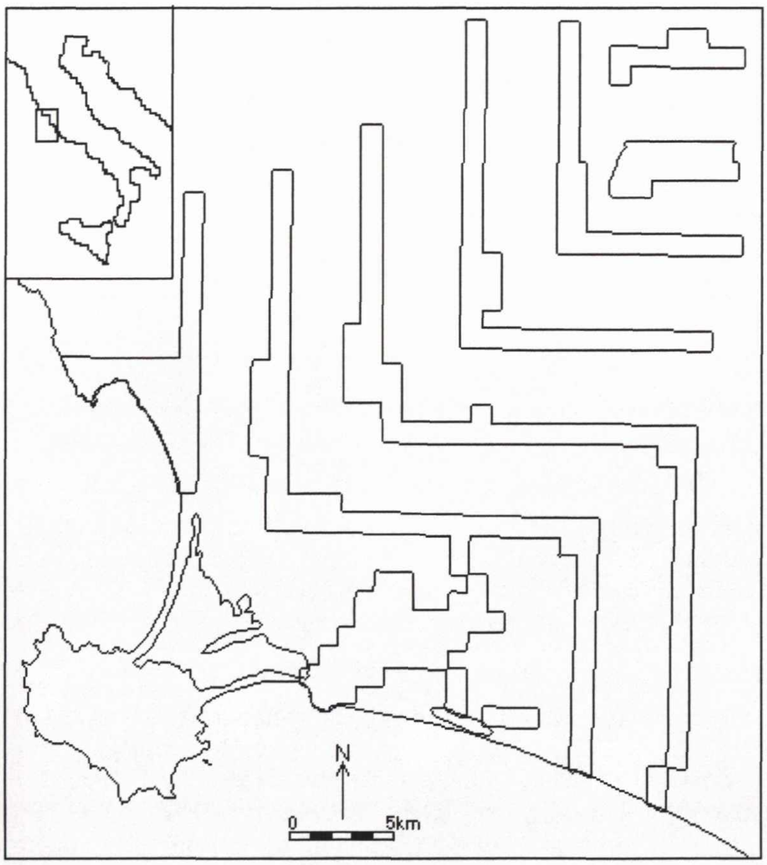

Figure 16.1: Location of study region and sampled transects

16.3 Methodology

The approach taken here considers the locations of sites identified within the sampled areas of the survey with reference to a variety of natural criteria: altitude, slope, aspect and solid geology. The purpose is to identify what kinds of location were associated with settlements and how these changed through time. Data for the first three variables was derived from 1:100,000 topographic maps of the *Istituto Geografico Militare* and the geological information from the corresponding maps of the *Servizio Geologico d'Italia.*

The method in each case is the same, the spatial distribution of classes of each of the variables (altitude, slope, aspect and solid geology) within the whole of the sample transects are compared with the locations of the sites. If sites were randomly distributed through the landscape one would expect 20% of the sites to be located upon limestone, for example, if limestone occupied 20% of the sampled area. The observed distribution of sites is systematically compared with the expected distributions. The difference between the two distributions is measured with a χ^2 test (Shennan 1988, pp. 65–76) which indicates if the difference is statistically significant. This technique provides a straight forward means of analysing features of the location (Kvamme 1992). The analysis may be taken further by considering further statistics derived from the χ^2 statistic; Yule's Q provides a means of assessing whether sites are positively or negatively associated with a particular variable, and the strength of the association is given by Φ^2 (Shennan 1988, pp. 78–81). The technique is simple and will detect statistically significant associations between distributions of variables in the landscape and the distribution of the archaeological sites, which may then be archaeologically interpreted.

The purpose of the analysis is first to identify any relationship between site and landscape and then to investigate how that relationship changes through time by repeating the analysis for each century between the 7th and the 2nd BC (*e.g.,* Figures 16.2–16.3). The calculations and results tables are tedious and are presented in detail elsewhere (Perkins 1995).[1]

Altitude above sea level was analysed in 50m bands; within the sampled area altitude rises from sea level to above 650m, yielding 13 categories to compare with the settlement patterns for each of the six centuries. The largest category of land is that below 50m which represents nearly 30% of the entire area. The distribution of altitude is presented in Figure 16.4.

Slopes have been measured as an average of blocks of land 300m square. These have then been classified into four bands, negligible for slopes 0–8%, slight for 8–16%, moderate for 16–25% and steep for slopes over 25% (USDA 1951). The distribution of slopes is presented in Figure 16.5.

Aspect is calculated as the average direction a slope faces over blocks of land 300m square. The aspect has been classified into none (*i.e.,* level ground),

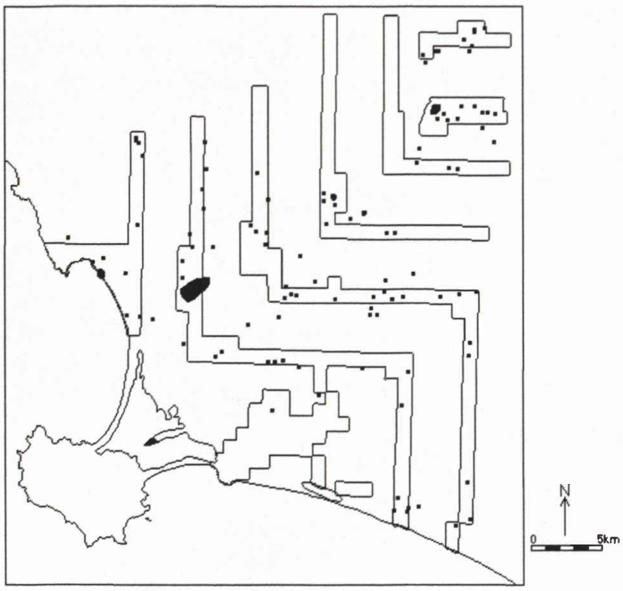

Figure 16.2: 5th century settlements (Etruscan)

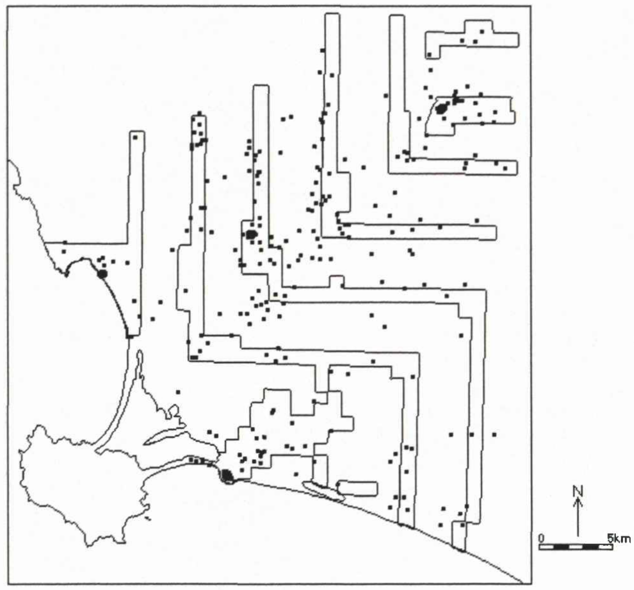

Figure 16.3: 2nd century settlements (Roman)

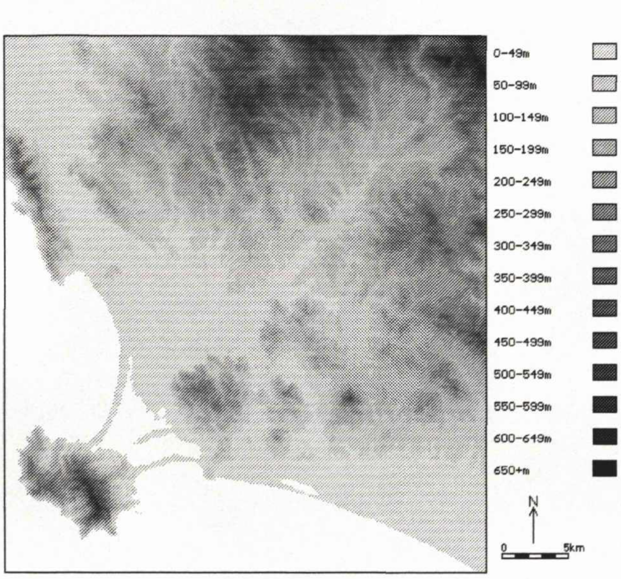

Figure 16.4: Distribution of altitude above sea level

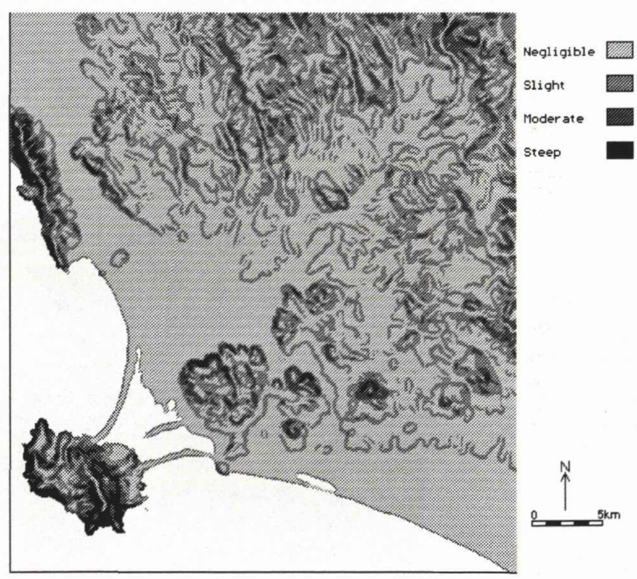

Figure 16.5: Distribution of slopes in the valley

north to north east, north east to east, east to south east *etc.* The distribution of aspects is presented in Figure 16.6.

The 15 geological classes are taken from the 1:100,000 geological maps and the distribution of the geology is presented in colour on CAA Web site.

16.4 Discussion and development

The purpose of this analysis has been to identify statistically significant elements of the relationship between landscape and settlement patterns. Only four components of the landscape have been considered, there are many others such as soil, rainfall, frost-free days *etc.* that contribute in a variety of ways which have not been taken into account. Nevertheless, the statistical analysis yields a variety of significant positive and negative associations between landscape elements and the settlement patterns from different centuries. So far each aspect has been considered in isolation, but each is only a part of the landscape, and should best be considered in combination with the other variables. Indeed all of these criteria are closely related, slope and aspect cannot exist without one another and both may be derived from the spatial distribution of altitude. However, Kvamme has demonstrated that in a heterogeneous landscape elevation, slope and aspect are not closely correlated

(Kvamme 1992, p. 130), thus we may have confidence in the results of the χ^2 analysis.

The problem remains of how the different landscape variables may be combined to produce more generalised models of the relationships between landscape and settlement patterns. Here a spatial approach is adopted where the observed relationships between each element of the landscape and the settlement locations are used to identify the areas in the valley which have been found to be associated with a settlement pattern. The technique is based upon that used in cartographic modelling to provide land evaluation maps (Burrough 1986, pp. 93–101) and proceeds as follows. Areas of the map containing values for each variable which have been found to be significantly associated with the settlement pattern are identified for each variable. The resulting maps are overlaid upon each other, and areas of the resultant map where all the variables coincide are the areas which have multiple associations with the settlement pattern. Two forms of map may be produced one for areas of significant positive association and the second for significant negative association.

16.5 Interpretation of the models of settlement locations

To generate the models only the settlement patterns derived from certainly occupied sites for each century, and associations significant at 0.01 (*i.e.*, 1 in 100 probability of being a chance association) were used. A drawback with this method of creating a model is that the variables are not directly comparable and the variables cannot be reliably weighted since it is not possible to determine if, for example, aspect should be given more importance than altitude (Burrough 1986, pp. 100–1). To solve this problem an association with a class of a variable was given a score of 1, the scores for the individual maps of the associations were added to produce an index of association between the landscape and the settlement pattern. Thus a score of four indicates that 4 associations coincide at that point on the map and a score of 1 indicates only a single association at that point.

Following initial examination of the results from all possible time slices the settlement history was divided into three periods to simplify the analysis and interpretation: the seventh century, the sixth to the third centuries, and the second century BC, coinciding with the pre-state, the Etruscan and the Roman settlement patterns.

In the seventh century there was generally very little association detected between the landscape variables and the settlement pattern, there were no negative associations and only limited positive association in the geology (Figure 16.7). The model defines a rather unlikely looking swathe of land in the hilly areas of the middle valley. The model suggests that settlement location in this period was not particularly associated with any of the elements of landscape considered here.

In the central period between the sixth and the third centuries two models may be generated, both based on all four landscape elements. The model (Figure 16.8) of positive association highlights the Pleistocene terraces in the Albegna valley and along the coastal strip as the areas associated on a broad basis with the settlement pattern (4 factors). The lowest lying areas of the valley and coastal strip have 3 positive associations as do many of the small low basins to the east of the Albegna and to a lesser extent small areas of the upper valley. A striking feature of the model is that many of the areas with four associations are very close to those with no positive associations suggesting that the landscape diversity that this represents may also be a consideration in the settlement pattern. This is most obvious in the coastal strip and the southern part of the Albegna valley.

The model (Fig. 16.9) of the negative associations with the settlement pattern between the sixth and the third centuries is to some extent the inverse of the model for the positive associations. The areas with a combination of four negative associations are concentrated in the hilly areas, particularly the hills between the coastal strip and the Albegna valley and the northern slopes of the Albegna valley. A large area of the upper valley, around the urban settlement at Saturnia has few negative factors. Some of the terraces in the middle valley and the basins to the east of the Albegna have a single negative association which derives from their altitude. This conflicts with the model of positive association where these areas generally have three positive associations. The model emphasises the proximity of areas with positive and negative associations, just like the previous model.

Together the two models illustrate the association between the Etruscan settlements and the low lying areas of the coastal strip and the Albegna valley. This is where the city at Doganella lies and many of the settlements. However the association between the landscape and settlement is also evident in the upper valley, as it is in the small basins and valleys between the Albegna valley and the coastal strip. A comparison between these models and the previous model for the seventh century suggests that there is an increased association between settlements and the low lying areas of the valley, particularly the Pleistocene terraces. This indicates an increased exploitation of the lowlands and may also be related to land reclamation schemes undertaken in the flat lands of the valley during the later seventh and the early sixth centuries when this land was occupied. The models equally highlight the lack of settlement towards the northern and eastern watersheds of the valley.

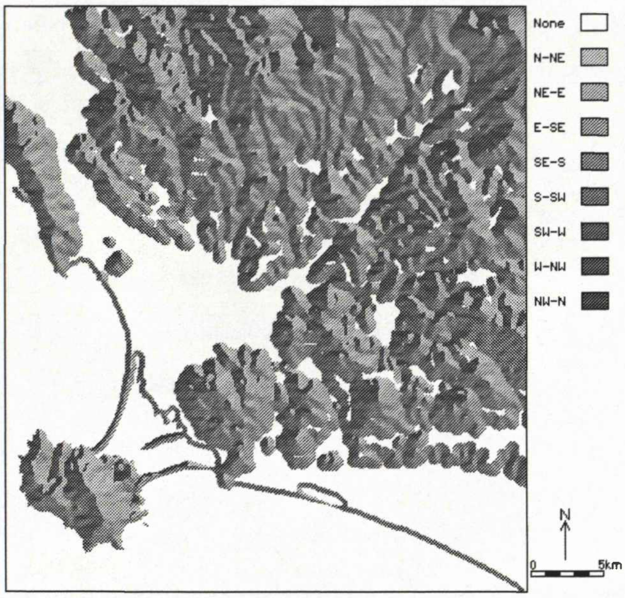

Figure 16.6: Distribution of aspects in the valley.

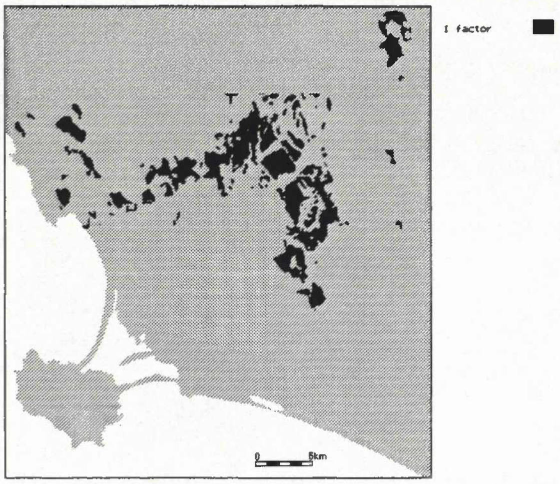

Figure 16.7: Model of areas with a positive association with 7th century settlement (grey indicates the land mass).

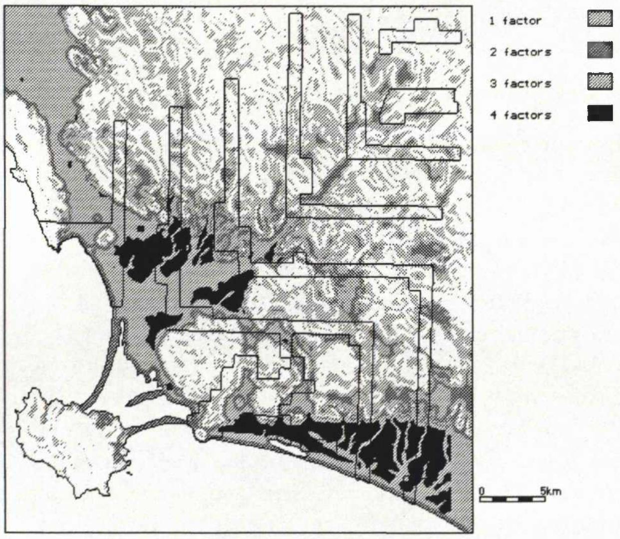

Figure 16.8: Model of areas with a positive association with Etruscan settlement

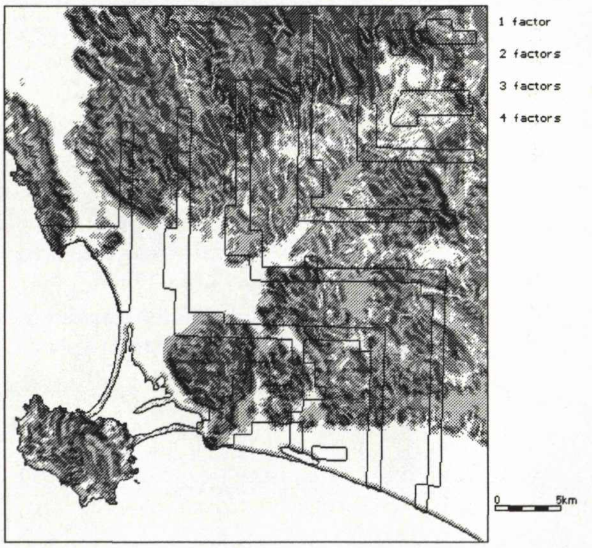

Figure 16.9: Model of areas with a negative association with Etruscan settlement

For the period following the Roman conquest the models change. The model of positive association is based on all four elements of the landscape (Figure 16.10) and is very different from that generated for the Etruscan period. The low lying coastal areas show less association and the areas with most associated factors are more widely spread through the valley. Generally the areas with four factors are found on the lower south facing slopes in both the valley and the coastal strip. The hills to the north of the Albegna, which were negatively associated with the Etruscan settlement now have some positive factors. This is reflected in the locations of settlements which are found in this area for the first time in the Roman period. The model of negative associations (Fig. 16.11) is derived from only the geology and altitude. Overall, few negative associations with the Roman settlement and landscape are revealed. The negative association of the lowest lying land contrasts with the positive association with the alluvium. The few areas where the negative associations combine are at low altitude with Cretaceous marl and limestone geology.

Comparison between the models for the Etruscan and early Roman periods shows that there are changes in the relationships between the landscape and the settlements. The city at Doganella dominates the

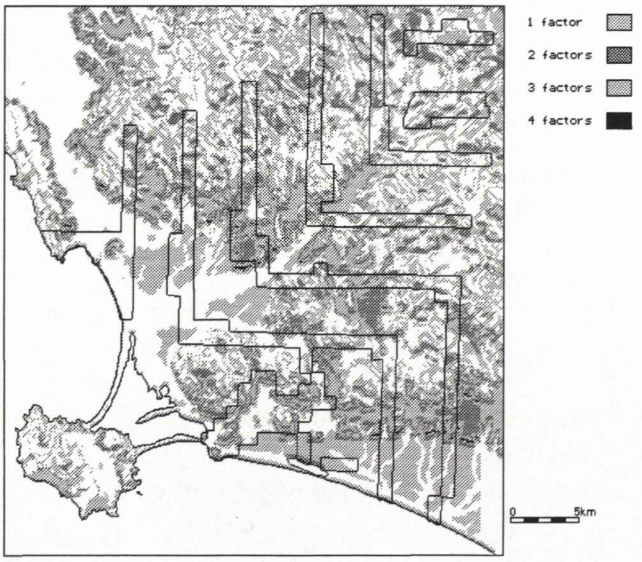

Figure 16.10: Model of areas with a positive association with Roman settlement

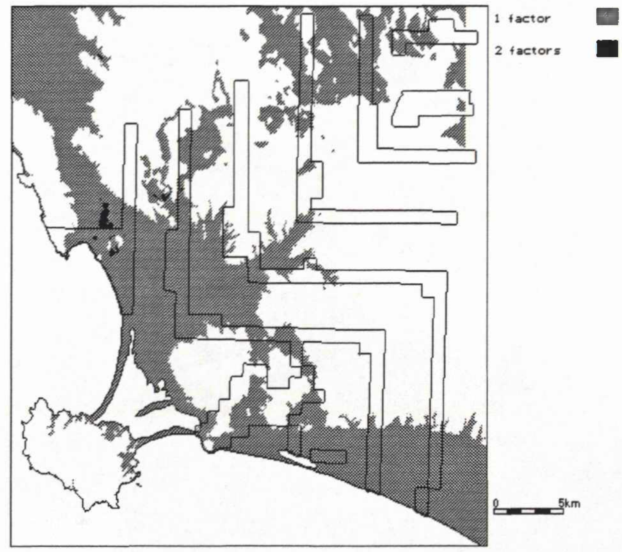

Figure 16.11: Model of areas with a negative association with Roman settlement

Etruscan model producing associations with both the land below 50m and the Pleistocene deposits. This suggests that the low, fertile terraces were associated with settlements. These level areas are suited to both arable cultivation and to a lesser extent viticulture. The alluvial plains are best suited to arable cultivation. The indication is that the settlement locations are associated with areas best suited to arable cultivation. In the Roman period the city at Doganella is no more and the positively associated areas move to the lower south facing slopes of the valley. This might be related to the intensification of viticulture documented by the production of wine amphorae in the valley and the Ager Cosanus (Manacorda 1978; Peacock 1977) because the low south facing slopes are well suited to vine cultivation, but the alluvial flood plain is not so well suited due to drainage problems. In both periods the proximity of positive areas to areas with negative association with settlement is a result of the diversity of the Mediterranean landscape, which enables exploitation of a variety of environments within small areas

16.6 Conclusions

This paper has described a GIS technique for identifying parts of the landscape which are associated with settlement locations and producing a general model visualising sets of relationships between the settlement pattern and the landscape. The model has been seen to provide a view of the changing settlement pattern which can be archaeologically interpreted with reference to the agricultural economy of different periods. This model can be seen as representing areas of the landscape which are associated, both positively and negatively with the position of settlements within the settlement pattern. As such it provides a generalised model of the catchment area of the entire settlement pattern within the region.

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Notes

1. Technical note: The GIS analysis was performed using the IDRISI package. The statistical analysis was achived with a combination of IDRISI and MICROSOFT EXCEL. Software was run on a IBM compatible PC.

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