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Visibility and Site Recovery in the Cecina Valley Survey, Italy

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One of the key issues in survey methodology today is the relationship between surface visibility and the discovery of archaeological sites on the landscape. As part of the Cecina Survey in central Italy, a treatment of visibility, which includes aspects of both geomorphology and ground cover, is developed in order to evaluate the strength of this relationship in quantitative terms. The results at Cecina show a strong positive relationship between visibility and site recovery. The spatial variation in visibility and its differential effects on site recovery over the landscape have deep implications for the analysis and interpretation of site distributions recovered during the course of the survey. An attempt is made to introduce a way of correcting for problems of visibility of this kind, concluding with a discussion of some of the wider implications of the results for the planning and conduct of surveys and for the interpretation of their results.

Introduction

This report considers the question of surface visibility as it affects the discovery of sites during the course of an archaeological survey. Over the last 10 years, there has been a growing awareness that this is a fundamental issue; yet few studies to date have managed to quantify the relationship between visibility and site discovery. Here we want to show how the treatment of visibility can be put into operation in a survey and to document how visibility affects the data recovered in the field. This will be done in terms of a case study, the Cecina Valley Survey in central Italy. The central purpose of the article is not to offer a preliminary report on the findings of the Cecina Survey; it is, rather, to focus on the methodological issue of visibility. In short, the present case study is intended as a contribution to the development of recovery theory (in the sense of Clarke 1973) as it relates to the archaeological survey.

It may be worth saying a few more words, by way of introduction, about the aims of the present study and how its results are to be regarded. At the most basic level we wish to show how visibility can be operationalized in a more comprehensive and objective manner than it has commonly been in previous surveys. Those doing surveys in the Mediterranean and in other parts of the world may want to adopt some aspects of this treatment—naturally with due allowances being made for local conditions, such as the availability of cartographic resources and the research questions that the project strives to answer. It needs to be stressed that the results presented below represent only those of this case study.

Obviously more case studies of this kind are needed, and some differences from one to the next are only to be expected. For many archaeologists the results with regard to visibility in the Cecina Valley, where a concerted effort is now paid to documenting the problem, may be disquieting. Our results have deep implications for the manner in which we view the settlement patterns presented in reports in the survey literature and how the results of surveys in progress are to be interpreted. Unsettling as this may seem for all of us, it has to be seen as a positive step in the growth of survey archaeology—a step toward a more complex perception of the realities of recovery.

It is for this reason that, after presenting the strong effects of visibility on site discovery in the first half of the report (the negative side of the story), we go on to demonstrate in the second part how one may correct for this problem (the positive side of the story). Let us note that the approach offered here, as a means of compensating for visibility, is just one of several alternative approaches that one may use.

Prior to 1980 little attention was paid in the survey literature to the visibility of archaeological evidence on the landscape. In the case of the Acconia Survey (1974–1980), part of a larger survey in the region of Calabria in southern Italy, it was the repeated coverage of the same land surface in different years together with the study of geomorphological windows on the landscape that originally drew our attention to the problem (Ammerman 1981; Ammerman and Bonardi 1981; Ammerman 1985a: 3–5).

At the same time, in certain parts of the world such as the NE United States, it became increasingly apparent to some archaeologists that not all sites were to be recognized by their surface remains. New techniques based on the use of shovel test pits were now introduced for the discovery of sites with little or no surface visibility (e.g., McManamon 1984; Shott 1985). Notwithstanding early enthusiasm for this approach, there appear to be fundamental limitations to the effectiveness of subsurface testing of this kind (Kintigh 1988). Moreover, such an approach can only be applied to relatively small areas and is not really possible for the investigation of a region as a whole.

In the Mediterranean world, by the mid-1980s, the treatment of surface visibility on a rough ordinal scale was incorporated into several surveys in Greece. A rating from 1 to 3 was adopted in the Megalopolis Survey (Lloyd, Owens, and Roy 1985: 222), while a scale from 1 to 10 was used both for the Levkas-Pronnoi Survey (Gallant 1986) and the Boeotia Survey (Bintliff and Snodgrass 1985; Bintliff 1988). In the latter case, an attempt was also made, on the basis of literary sources, to consider the relationship between the sites actually found in the survey and those said to occur in the region (Bintliff and Snodgrass 1985; Bintliff 1988).

In a broader study, Schiffer (1987: 235–262) reviewed the range of factors that may influence the visibility of a given site on the modern land surface. More recently, to mention just several examples from the Mediterranean literature, a continuing awareness of the issue is displayed by the survey on the Greek island of Keos (Cherry, Davis, and Mantzourani 1991; more on this below) as well as by the Agro Pontino Survey in central Italy (Voorrips, Loving, and Kamermans 1991) and the Hvar Survey in Dalmatia (Gaffney, Bintliff, and Slapsak 1991, where attention is primarily paid to visibility on the intra-site level).

While a broad concern with the question of surface visibility is present in the literature of the last 10 years, few attempts have been made to explore the problem in any real depth. In the design of surveys, the quantitative analysis of the relationship between visibility and site recovery seems to have been deferred for one reason or another. It is worth considering briefly some of the possible reasons for this. On the one hand, other important issues—such as the debate between the advocates of sampling coverage and those arguing for full coverage (Fish and Kowalewski 1990)—have tended to be the active topics of discussion.

Perhaps more importantly, we have to remember that survey archaeology is still comparatively young—a field still in need of asserting its place in archaeology. To acknowledge the problem of visibility, to admit that a site can occur on the landscape and yet may not always be recoverable, would seem to be a move not serving the cause of the survey. If anything, it would only provide fuel for the detractors of survey archaeology. On the other hand, the tendency toward the intensification of field coverage, beginning in the 1970s and growing in the 1980s, seemed to offer a natural way out of the problem. As the landscape is covered more intensively and more attention is paid to lighter scatters of material on its surface, more sites (and what are sometimes called "off-sites") are invariably found through survey (Cherry 1983).

In the face of such apparent progress (not without complications, due to problems of the stochasticity of surface material, as we shall see below) dwelling on the issue of visibility would only seem to encourage an inhibiting relativism, undermining the interpretation of survey results. From this perspective it is possible to understand the ambiguity found in the recent literature—the tension between an increasing awareness of the problem of visibility and a persistent optimism that survey data are acceptable as they stand (e.g., Barker 1991).

In the Cecina Survey an attempt is being made to take a more critical approach to the problem. We want to move beyond the impressionistic rating of visibility in a survey. In our treatment of surface visibility, account is taken of both geomorphology and ground cover. How this is put into operation in the design of the Cecina Survey will be described in the section on the treatment of visibility below. It is worth noting here that cartographic resources available to the project, topographic and cadastral maps at a scale of 1:5000, have greatly facilitated the work at Cecina. What is found, as we shall see, is a clear association between surface visibility and the recovery of sites. Instead of regarding this finding as a setback for the survey, we see it as establishing a more realistic framework for the interpretation of survey results.

The Cecina Survey

The Cecina Survey takes its name from the river valley which begins in the Colline Metallifere of Tuscany, passes near Volterra and feeds into Thyrrenian Sea at the town Cecina (see FIG. 1). Begun in 1987, the Cecina Survey is a long-term field project, now in its seventh year. Briefly, the

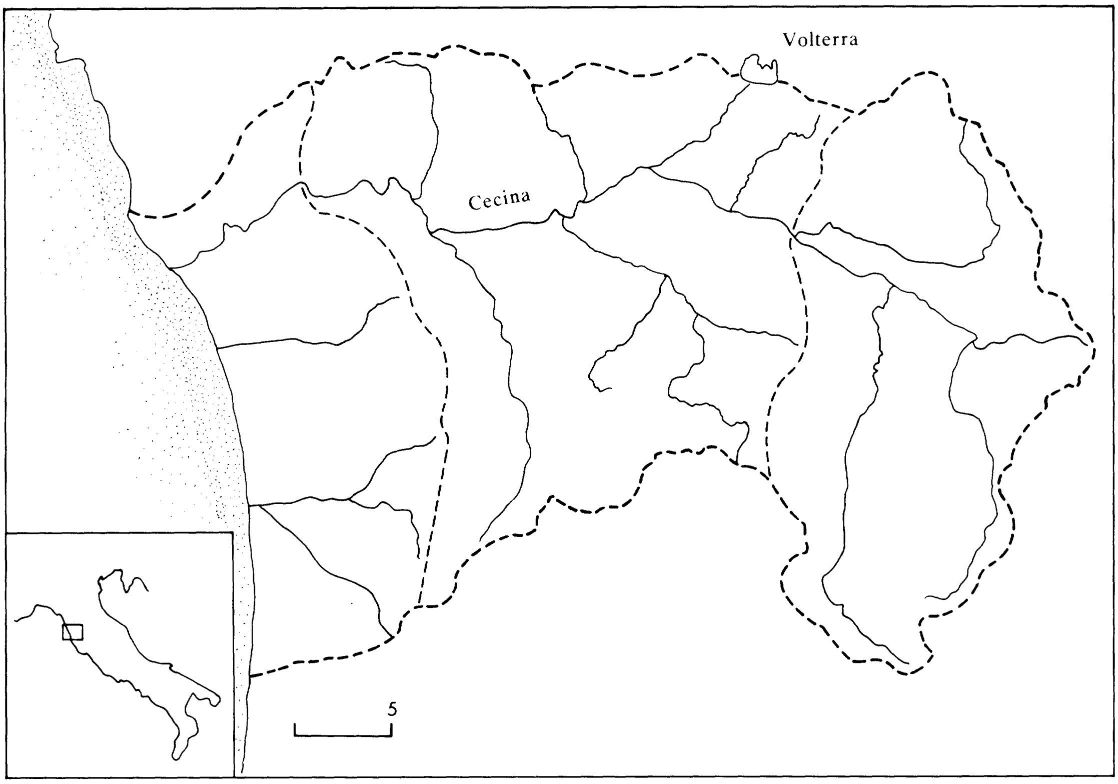


Figure 1. Map of the Cecina Valley on the western coast of central Italy. Three main environmental zones were distinguished for purposes of the survey. Delimited by dashed lines on the map are the coastal plain, the hills behind it, and the interior with higher elevation.

main aim of the study is to investigate the distributions of settlements in the time span from Etruscan through Late Roman times. While the survey records the presence of artifacts of all periods encountered on the landscape, decision making—in keeping with the primary research goals of the survey—is keyed to the recovery of sites that date between 600 B.C. and A.C. 600.

Mention should also be made here that the basic approach to the survey is that of taking the site as the target of discovery. This would be in contrast with a survey that takes the recording of individual artifacts and their distributions on the landscape as its objective (that is, a non-site approach to a survey). Recently, in this journal, attention has been drawn to the problems of stochasticity for single artifacts and light surface scatters that commonly arise in the case of land surfaces subject to cultivation (Ammerman 1993).

In order to convey a better sense of the nature of this problem—one still commonly not well understood in the literature on surveys—it is useful to turn to a simple simulation of the relationship between the material appearing on the land surface and that occurring in the plowzone. This may better help to explain our choice of the site and not the single artifact or light scatters as the basic unit in the present analysis. Perhaps the easiest way for most archeologists to gain a sense of the stochastic nature of material on the land surface in areas subject to plowing is offered by simulation. It will be noted, in passing, that the original formulation of the problem goes back to an article by Ammerman and Feldman (1978), which requires, however, a substantial mathematical background.

Several recent studies have looked at the question of the ratio between the number of pieces in the plowzone and those occurring at any one time on the surface (e.g., Ammerman 1985b; Odell and Cowan 1987). While this value will vary in part with the depth of plowing and other local factors, it is often found, on average, to be on the order of 20:1. In addition, as a first approximation, it is possible to regard the circulation of an artifact between the plowzone and the surface as taking place essentially according to a random process.

Let us consider a simple Montecarlo simulation in which a given number of pieces start in the plowzone and the ratio is taken to be the one mentioned above (that is, a ratio of 1 to 20, or a probability of 0.05 that a given artifact is on the surface at any one time). Further, let us also suppose, for the sake of argument, that only 1 out of 5 artifacts is fully diagnostic in chronological terms (in many cultural contexts such a value is probably on the optimistic side). In any given trial of the simulation, each piece is represented by a number (for example, in the case of 10 pieces these would be the numbers 1 through 10) and the first 20% of the pieces (numbers 1 and 2 in this case) are taken to be the diagnostic ones.

The simulation program, based on a standard Montecarlo treatment, was written by Keith Kintigh, who also ran the 10 trials for each of the five cases. Table 1 lists the actual results produced by the trials, using 100 pieces. In a given trial of the simulation, each piece (number) is made to come up against a random number, and those meeting a value number of 0.05 or less are moved to the surface, while those meeting a value between 0.06 and 1.0 remain in the plowzone. We have kept the simulation quite simple (using a fixed surface to plowzone probability and a given ratio of diagnosticity throughout) and the number of trials short for purposes of brevity in the exposition of the stochastic nature of surface material. Note also that the simulation concerns only the relationship between pieces in the plowzone and these making their appearance in the surface (obviously at most sites there will be pieces in the ground below the plowzone which have no chance of reaching the surface).

In order to illustrate the levels of stochastic variation that arise, 10 trials are carried out in each case. It is important to emphasize that what one sees in the field at any one time corresponds to an individual trial and not the average value of a series of trials (an error in presentation made in Odell and Cowan 1987, as noted in Yorston, Gaffney, and Reynolds 1990; see also Ammerman 1993: 371). The results of this exercise are given in Table 2. In the case of 10 pieces, we see that only in two out of 10 trials one piece makes its appearance on the surface and none of the trials yields a diagnostic piece.

In the next case (30 pieces) there is a range of 0 to 4. Eight out of ten of the trials have two pieces or less on the surface and there is only one trial which has a diagnostic surface piece. In the following case, that of 100 pieces, the range is even greater (1 to 8); here three out of 10 trials still result in only two or fewer pieces on the surface. Once again more than half of the trials (six out of 10) still produce no diagnostic artifact, which means that the thin scatter of material on the surface cannot be closely dated much of the time.

In this light it is not surprising that surveys which take an artifact orientation and try to record very small scatters at specific places on the landscape often lead to considerable difficulty in off-sites surveys since many such occurrences cannot be very well dated (e. g. Cherry, Davis, and Mantzourani 1991: 53). At the level of 300 pieces—a more substantial number of artifacts in the plowzone—we begin to consistently find a fair number of pieces that make their appearance on the surface: in the present case at least 9 pieces in any one trial. And a few diagnostic pieces (2–6) now appear regularly. Finally, in the last case, the material on the surface becomes more conspicous (with a range of 19 to 34 pieces), and once again a few diagnostic artifacts are consistently encountered in a given trial.

Table 1. Results of the simulation program produced by ten trials in the case of 100 pieces. The individual numbers to the left of the asterisk are the diagnostic pieces.

Trial	*Diagnostics*Other*
1	* 44 95 100
2	12 16 * 21 23 81 96
3	* 21 33 48 70 72 87
4	15 17 * 47 51 64 88 99
5	* 23 62 100
6	2 18 * 39 42 44 50 83 90
7	* 44 73
8	* 22 68 94
9	* 91
10	6 * 56

One of the points that this exercise makes is that when the number of pieces in the plowzone is comparatively small (less than 100 pieces), stochasticity expresses itself in the very presence or absence of material on the surface. In other words, in this context there will be a tendency for a given site to "flicker on and off," depending upon the time when the place is visited. This leaves one with little confidence that, from one year to the next, scatters of this kind can be observed with consistency. While those doing surveys today are often drawn to the notion of recording the spatial distributions of such light scatters, the interpretation of this kind of evidence poses fundamental problems, due to its inherent stochasticity.

At the same time, as the number of pieces in the plowzone becomes somewhat larger, the effects of stochasticity no longer are so much a matter of presence and absence but start to take on a different form. There is still a wide range in terms of absolute numbers of pieces on the surface at any one time, and attempts at measuring the density of a surface scatter now become the issue. Density values vary dramatically at a site from one trial (year) to the next. The implication here is that due caution is required if one intends to use an index value of density for purposes of defining a site or an off-site: what is observed as a site one year may present itself as an off-site the next year.

Returning from this digression to the Cecina Survey, the

Table 2. For each number of pieces (respectively 10, 30, 100, 300, 500), the results of the simulation of material circulating in the plowzone are given for 10 separate trials. All of the trials are based on a surface to subsurface ratio of 1:20 as well as a ratio of 1 to 5 for diagnostic pieces (see the text). The numbers in the table represent the count of pieces appearing on the surface in each trial (representing in the simulation a time when the surface is examined); the numbers in parenthesis indicate how many of the surface pieces are diagnostic. The bottom row, which gives the range of values observed over the 10 trials, provides an index of the stochastic variation found among the trials in each case.

	Number of pieces				
Trial	*10*	*30*	*100*	*300*	*500*
1	1(0)	2(0)	3(0)	15(6)	19(3)
2	0(0)	2(0)	6(2)	13(4)	22(2)
3	0(0)	0(0)	6(0)	12(3)	34(6)
4	0(0)	1(0)	7(2)	11(2)	26(6)
5	0(0)	3(0)	3(0)	15(3)	25(4)
6	0(0)	2(0)	8(2)	17(2)	23(5)
7	0(0)	1(0)	2(0)	15(3)	30(3)
8	1(0)	4(0)	3(0)	9(4)	26(2)
9	0(0)	2(0)	1(0)	13(4)	20(4)
10	0(0)	1(1)	2(1)	11(4)	30(4)
Range	0–1(0)	0–4(0–1)	1–8(0–2)	9–17(2–6)	19–34(2–6)

considerations outlined above were those that we had in mind in focusing on sites (as opposed to single artifacts or light, off-site scatters) in our study of visibility. While scatters of all kinds were recorded in the survey, only sites in the sense of clear concentrations of material on the land surface are used in the present analysis. This is also in keeping with the substantive research interests of the Cecina Survey on settlement patterns between 600 B.C. and A.C. 600.

In environmental terms, we can distinguish three main zones within the research area: the coastal plain which is the most productive zone in agricultural terms and which today witnesses intensive exploitation; the hilly zone just behind the coastal plain with its more rugged relief and more varied ecology; and the higher interior zone, much of which is covered with *macchia*. In the early years of the Cecina Survey, most of the fieldwork was done on the coastal plain. A brief history of the motivation for the survey and the evolution of its sampling strategy is provided by Regoli (1992; for recent commentary on the subject of sampling in surveys, see Nance 1983, 1994).

In the present study, as we shall see below, use is made of 25 units on the coastal plain, each measuring a kilometer on a side. Since inference is made here specifically with regard to these 25 units and not to the larger population of squares in the area surveyed, we shall not go into a more detailed discussion of the sampling design. What is of interest here for our present purposes is an evaluation of the degree to which there is homogeneity or heterogeneity in visibility among the units that have been actually sampled. (Terrenato [1992] provides a preliminary report outlining the basic goals and field methods of the survey and presents some of the primary results of the initial work on the coastal plain.)

The Treatment of Visibility

It is common for the archaeologist who does survey work in an area such as the Mediterranean to learn from experience that not all places on the landscape offer the same opportunity for the discovery of sites. For example, in walking over a field with a growing crop that makes it difficult to see the ground, there will be a low expectation of finding a site or a scatter of artifacts on the landscape. To take another case, due to geomorphological and pedological processes, a given place may have witnessed inflation in recent times, thus making the chances for the recognition of archaeological sites there equally low.

Indeed, it is entirely possible that ground cover and geomorphology both may be acting at the same time to limit site visibility in a particular area. Clearly, the range and relative importance of the various factors influencing site discovery will vary with local conditions, and from one survey to the next. If, however, there is an awareness on the part of survey archaeologists that visibility, at some level, is affecting the results of their surveys, few attempts have so far been made—as we saw in the opening remarks—at measuring or monitoring the scale of this problem. The key step, it would appear to us, is that of putting this broad qualitative awareness into operation—of developing an adequate treatment of visibility.

The Cecina Survey offered a favorable context for tackling this methodological problem. To begin with, the survey was planned as a long-term project; experience gained in one year could be used in developing the treatment of visibility in the next. At the same time, as mentioned above, good cartographic resources were available for this part of Tuscany. These included a series of recently-drawn geographical maps at a scale of 1:5000 (*Carta Tecnica Regionale*) as well as a series of cadastral maps at the same scale (*Mosaico Catastale*). The latter maps show individual parcels of land ownership, thus providing a good representation of modern land use. Having access to maps of this kind, with their detailed definition of field boundaries, proved useful both for the recording of archaeological evidence and for the field-by-field mapping of crops at the time of survey coverage.

In addition, a series of orthophoto maps (*Ortofotocarta*, maps showing geometrically corrected aerial photographs with contour lines drawn on them) at a scale of 1:10,000 could be used for the survey. Finally, maps of the geomorphology of the area, drawn at the scale of 1:25,000, had recently been produced by Mazzanti (1986) and Raggi and Bicchi (1985). Given the availability of such resources, there was the opportunity to do a pilot study focusing on the relationship between surface visibility and site recovery. Thus, as part of the work on the coastal plain, we decided to undertake the present study within the framework of the larger survey project.

In 1988, the second year of the Cecina Survey, the first steps were made toward the operationalization of surface visibility: the systematic recording of the conditions of the land surface at the time of coverage (that is, the kind of crop growing in each field and its state of cultivation) was now incorporated in the survey.[1] At the same time, we began to think about the way to combine these observations on current land use with those on geomorphology. For the treatment of geomorphology it was realized that we could make effective use of the map published by Mazzanti (1986; see also Terrenato 1992: fig. 6 for a small scale version of this map where sites have also been plotted).

By locally ground-truthing Mazzanti's map, his representation of geomorphology was found to be reliable. In addition, as a means of increasing the fieldwalkers' sensitivity to soils and geomorphology, relevant notes were now regularly made for each field surveyed. An example of the mapping of one 1-km square is shown in Figure 2.[2] The pie diagram above the map gives the percentage of area falling, respectively, into two classes: those places where recent alluvium is observed and inflation of the land surface has occurred over the last 2000 years (the dark shading on the map and the left side of the pie diagram; this unit will be denoted below by the letter "g") and those places (of various nature in terms of their geopedology) where the land surface has experienced little or no inflation over the same time span (the light area on the map and the right side of the diagram; denoted by the letter "G").

The treatment of modern land use or ground cover proved to be more complicated. It involved several steps. The initial one was to classify each field in terms of the crop growing there and to describe the condition of the land surface with regard to cultivation. A split classification was adopted at this stage. On the basis of what was observed in the field in 1988, it was found that this factor could be represented, more simply and yet quite effectively, in terms of four basic categories. As illustrated in Figure 3, these are plowed land, harrowed land, light vegetation cover, and heavy vegetation cover. The pie diagram to the upper left of the map shows the relative proportion of the sampling unit's area belonging to each category.

In this case, more than half of the unit is covered by heavy vegetation. As we shall see below, the pie diagram to the upper right of the map represents a further step where these four categories have been reduced to just two primary ones (see TABLE 3). The reason for doing this was to facilitate the eventual cross-classification between ground cover and geomorphology (TABLES 4, 5).

Let us now turn then to Table 3, which summarizes the results in terms of the four categories of ground cover for all 25 of the units that comprise the database for this study. It is worth noting here that all of these units have been surveyed using the same approach to coverage of the land surface as well as to the recording of sites. The first two categories (plowed and harrowed) both have densities of more than 5 sites per sq km. In contrast, the third category (light vegetation) has a much lower value, while the fourth category (heavy vegetation), which covers the most area (a total of 11.44 sq km), has a density of sites close to zero.

Already we can begin to see the major effects of ground cover on the visibility of sites. On the basis of these results,

1. It was at this time when Ammerman began to serve as the consultant on research design for the survey.

2. The location of this unit corresponds to the position of the pie diagram in the sixth row from the bottom in Figure 5.

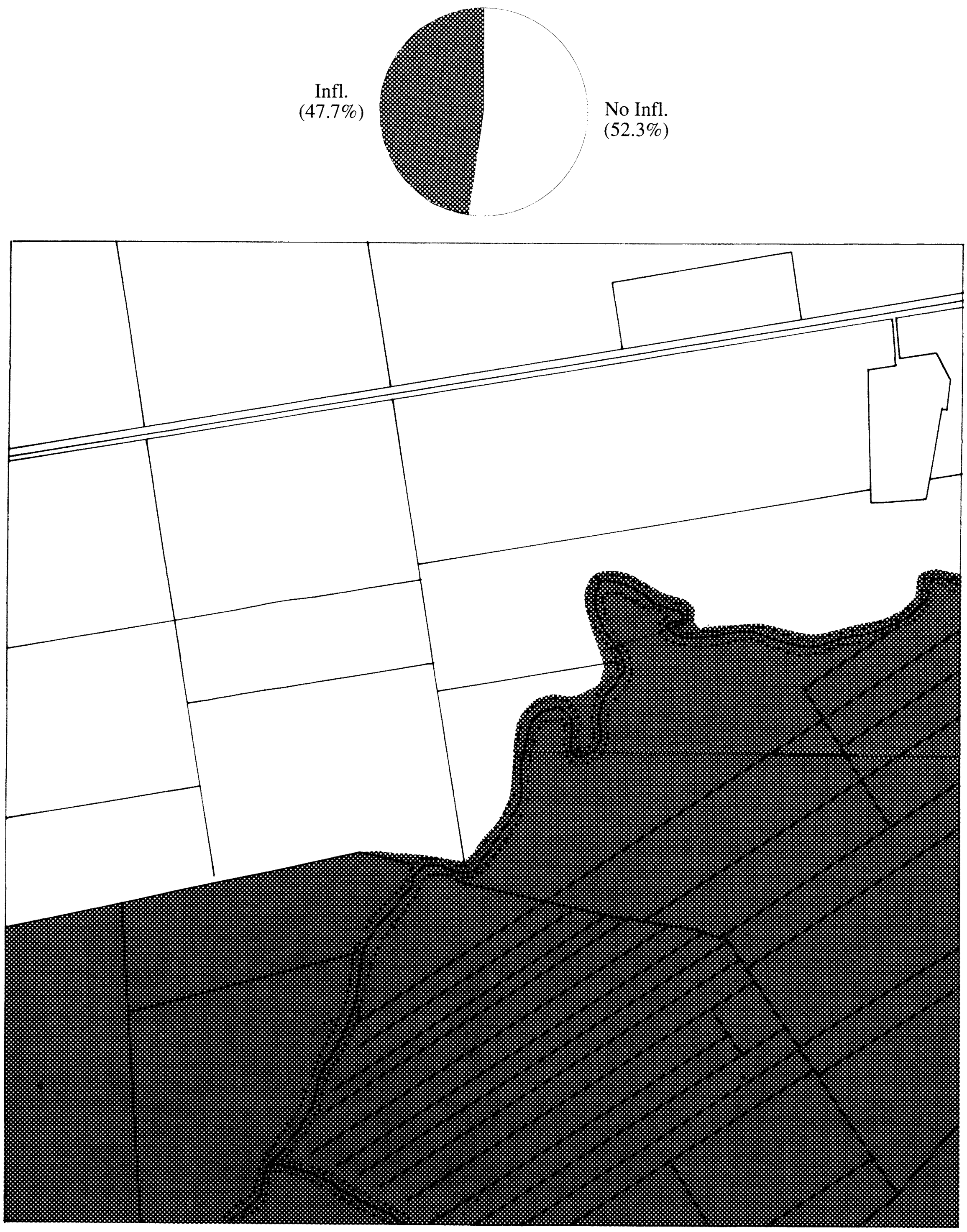


Figure 2. The mapping of visibility in terms of geomorphology is given in this example of a sampling unit, a square measuring 1 km on a side. The map shows two categories of geomorphology: places where alluviation in more recent times has resulted in inflation of the landscape (dark shading). Light shading is used to represent those places with little or no inflation of the landscape over the last 2000 years. The pie diagram over the map gives the percentage of the area of the unit that belongs to each category.

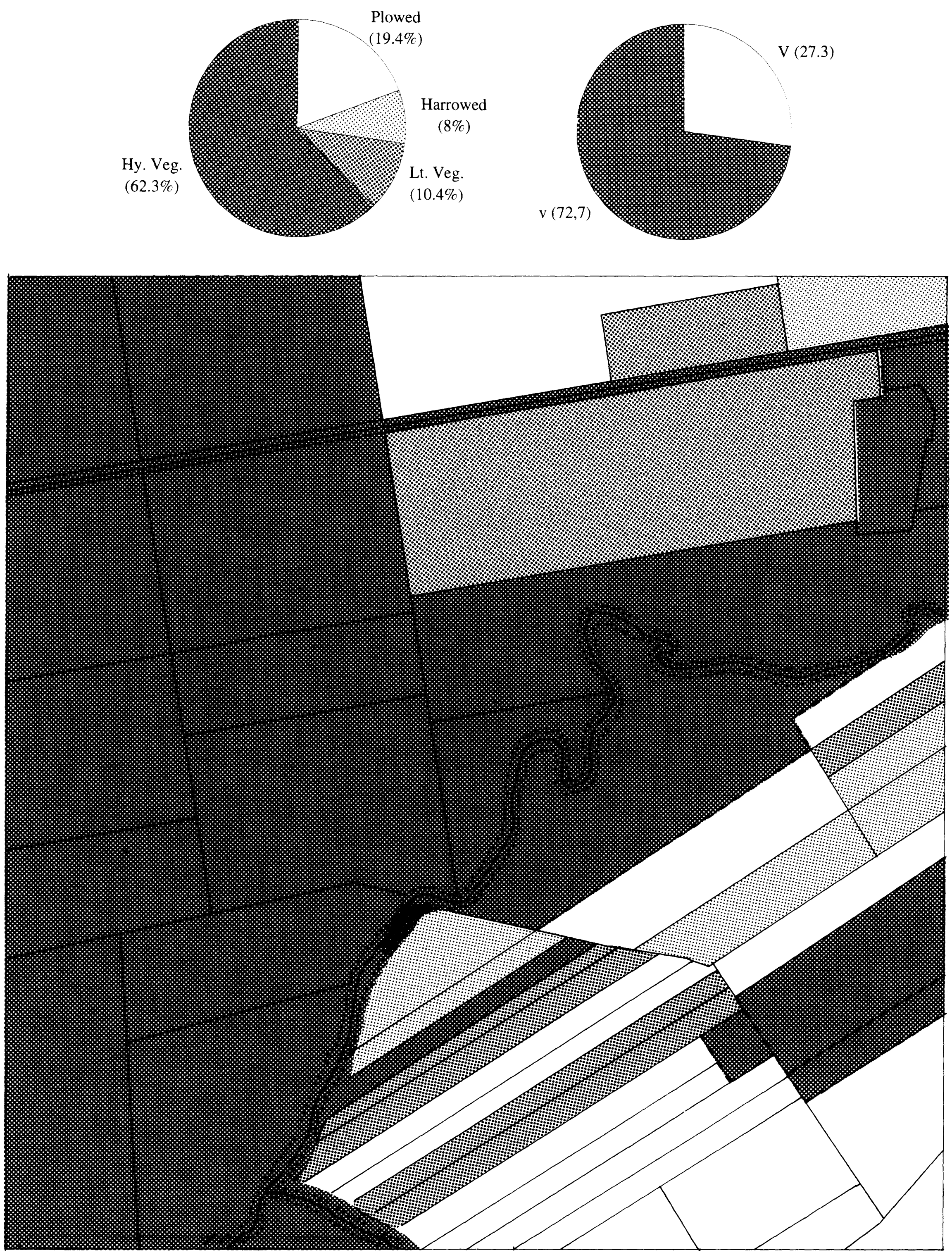


Figure 3. For the same sampling unit as shown in Figure 2 the mapping of visibility in terms of ground cover is done on the basis of four categories: heavy vegetation cover, light vegetation cover, harrowed land, plowed land (correspondingly, from darker to lighter shading). Again the pie diagrams above the map give first, on the left, the percentage of the unit's area for each of the four classes. The pie diagram on the right shows the percentage of area when the treatment of ground cover is reduced to two categories (see text).

Table 3. For each of the four categories of ground cover (the lowercase letters in the second row from the top, see the text) the table gives the number of sites, the total area, and the density of sites. The top row (V = vegetation-free; v = vegetation cover) indicates the further grouping of these categories (see the text).

	V		*v*	
	pl	*ha*	*lv*	*hv*
Sites	48	20	8	2
Area in sq km	7.68	3.96	2.40	10.94
Sites/sq km	6.24	5.04	3.32	0.18

as the next step (mentioned above) we merged the first two categories (in effect those fields that are vegetation-free; the category will be denoted by the letter "V") and the third and fourth categories (those fields with vegetation cover; denoted by the letter "v").

This treatment of ground cover allowed us to make a cross-classification with geomorphology, the other main component of visibility, in a way that was not too cumbersome (that is, one that did not involve too many classes). This meant that surface visibility as a whole could be represented economically in terms of only four classes (the cross-classification between two categories of geomorphology and two categories of ground cover). An example of such a two-way classification for an individual sampling unit is given in Figure 4. For instance, those fields with no vegetation cover and little or no inflation of the land surface have the lighter shading. The pie diagram above

Table 4. For each class of visibility, based on the two-way classification, according to geomorphology and ground cover, the respective values are given for number of sites, total area, and site density.

	GV	*gV*	*Gv*	*gv*
Sites	69	1	6	2
Area in sq km	9.74	1.93	11.44	1.89
Sites/sq km	7.08	0.51	0.52	1.05

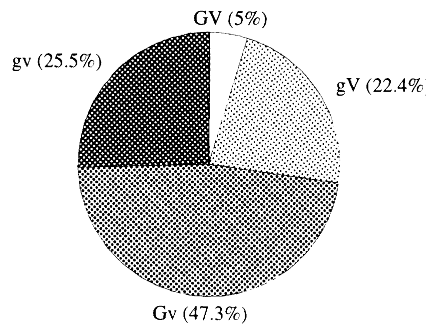
the map indicates the percentage of the unit's area falling in each of the four classes (respectively, GV, gV, Gv, gv).

In Figure 5, the results of the two-way classification are displayed for all of the 25 units. Here the pie diagram for each unit is shown at its respective location in the map. We have intentionally placed emphasis on graphic display in our work at Cecina so that the information can be readily comprehended both by students participating in the fieldwork and by other archaeologists who may not have a background in quantitative methods. The larger pie diagram at the top of Figure 5 shows the percentage of the area belonging to each class for all 25 of the units now taken together. In effect, this represents the average situation, with regard to visibility, among the 25 sampling units on the coastal plain. It shows, for example, that only about one-quarter of the area falls in the highest and most promising visibility class (GV).

At the same time, it will be noted that the individual units, the smaller pie charts on the map, show considerable variation around the mean values of the four classes. In the best case the most visible class (GV) covers as much as 77%

Table 5. Number of sites discovered and expected in relation to visibility. Presented in the form of a cross-classification of geomorphology against ground cover, the first part of the table (top) gives the number of sites discovered in each of the four "visibility classes" (see the first row of TABLE 4). The second part (below) shows first, in parentheses, the percentage of the total area of 25 sq km presented in the same form (see the pie diagram at the top of FIG. 5) and, next to it, the expected number of sites (obtained by multiplying the respective percentage by the total number of sites; see the text) for each of the four classes, using the hypothesis of independence between visibility and site discovery.

	Number of sites in each visibility class		
	V	*v*	*Total*
G	69	6	75
g	1	2	3
Total	70	8	78
	(Percentage of total area) and expected number of sites		
G	(38.96) 30.4	(45.76) 35.7	(84.72) 66.1
g	(7.72) 6	(7.56) 5.9	(15.28) 11.9
Total	36.4	41.6	78



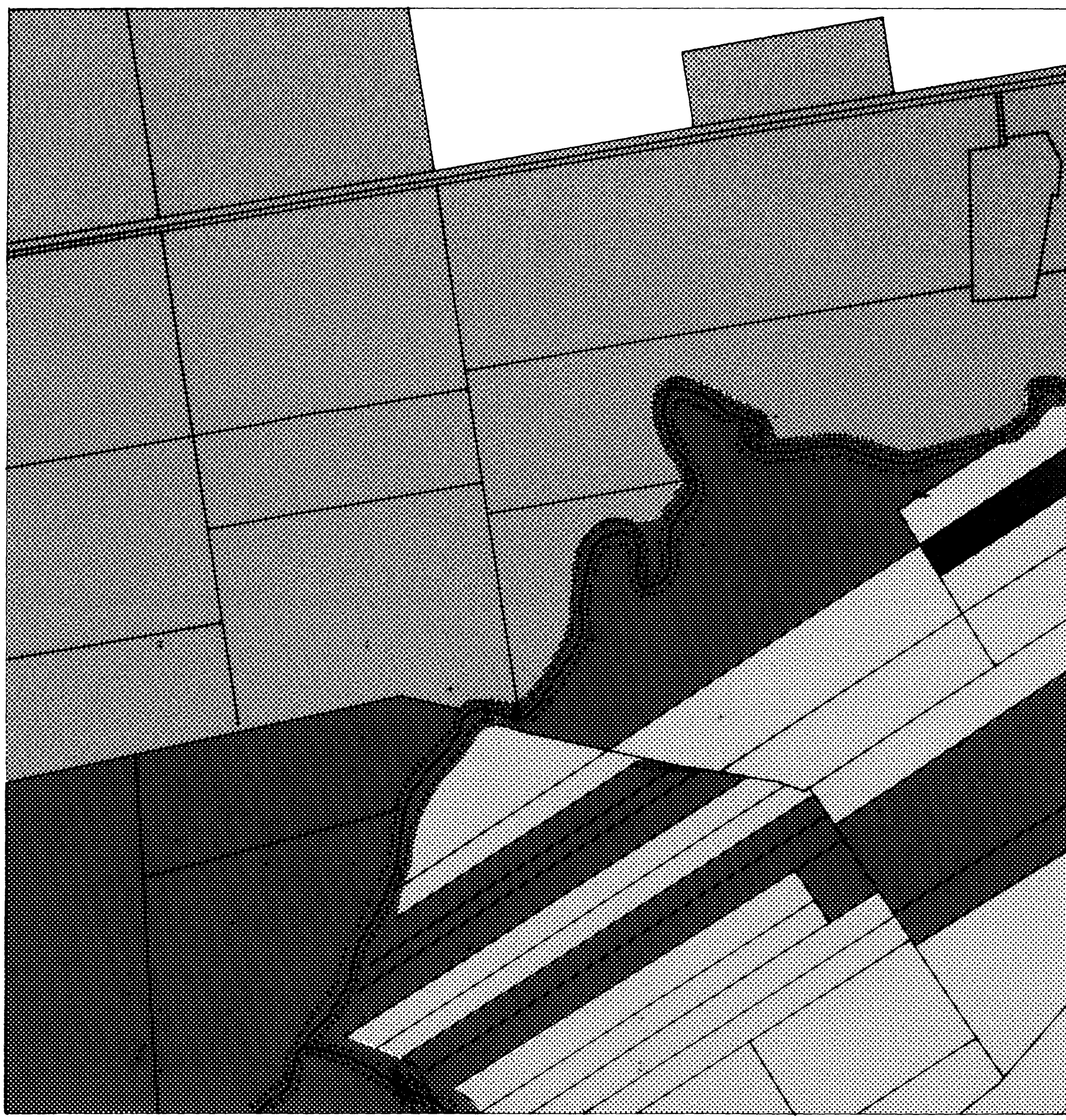


Figure 4. An example of the two-way classification of visibility (two categories of geomorphology against two categories of ground cover). The unit is the same one as that used in Figure 2. Again the pie diagram gives the percentage of the unit's area that falls in each class. The four classes are GV, gV, Gv, gv (for their meaning see the text).

of the area. In contrast, there are five cases where the other three classes constitute more than 90% of a given unit. There is a good indication then that visibility on the coastal plain at Cecina is quite heterogeneous in spatial terms.

The Analysis of Results

The results for the four classes of visibility for all 25 units are given in Table 4. The first class (GV) has a total of 9.74 sq km; this corresponds to 39% of the area as a whole. The vast majority of the sites, a total of 69 for all periods, happen to be identified in connection with this class. The highest class of visibility thus yields an average density of 7.1 sites per sq km. In contrast, a total of only 9 sites were found for the other three classes of visibility (gV, Gv, gv), even though, taken together, they comprise 61% of the area. All three of these classes, as shown clearly in Figure 6, have much lower values for site density than does the first class. The density values here are all very low: 1 site per sq km or less. Thus, there is evidence that site discovery is closely linked with those places offering good surface visibility.

Another way to look at this pattern of association is presented in Table 5. On the left the number of sites recovered for each of the four classes (the values in the first row of TABLE 4) is placed in its respective cell of a two-way table. On the right-hand side, a corresponding table gives first in parentheses the percentage of the total area falling in each class (see second row of TABLE 4 and pie chart at the top of FIG. 5) and then below it the number of sites that one should expect given the hypothesis of independence between site discovery and visibility (obtained by multiplying the respective percentages by the total number of sites found). Those familiar with statistics will recognize this as the basic setup for a chi square test of independence; the chi square value in this case is 80.5, with three degrees of freedom, which is highly significant.[3] The important thing here is not to dwell on formal aspects of the statistical test but to underscore the strong pattern of positive association observed for the first class of visibility.

In addition, we may want to note that of the two main factors, ground cover and geomorphology, the former appears to play the more active role on the coastal plain at Cecina. In conclusion, at the level of the study area as a whole, we find that there is a clear pattern of association between surface visibility and site recovery.

What are some of the immediate implications of this finding? To begin with, it is unrealistic to assume that we have found all of the sites in the area surveyed. It is much more reasonable to think that many as-yet undiscovered sites are present in those parts of the landscape with low visibility. In the present case, perhaps the best estimate for the total number of sites within the survey area is on the order of 177 sites. This figure is obtained by taking the density value for the first class (GV; 7.1 sites per sq km in TABLE 4) and multiplying it by the total area of 25 sq km. This projected site total would be more than twice the number of sites actually recovered in the survey. This corrected figure itself may be only a conservative estimate since, if one were to repeat the coverage of areas with good visibility, additional sites might well be found there, thus raising the site density for this class.

Our main aim here is not to establish such a projected figure in final form, but rather to demonstrate the kind of correction that needs to be made. The point that we want to make is that in advancing arguments about such things as the number of sites on the landscape and their spatial distributions, it will be misleading simply to take the sites found and use them, quite literally, as the basis for interpretation. Clearly, in light of what we now know, corrections will have to be introduced before sound inferences can be made from survey data.

It is also useful to consider the relationship between visibility and site discovery at a finer scale, the level of the sampling units themselves. The reason for this is that in surveys one is interested both in the total number of sites in a region and in their patterns in space. The question that we now want to ask is: do the units all exhibit much the

3. The complete chi-square calculations are as follows:

$$\chi^2 = \frac{(69-30.4)^2}{30.4} + \frac{(6-35.7)^2}{35.7} + \frac{(1-6)^2}{6} + \frac{(2-5.9)^2}{5.9} = 80.52$$

With three degrees of freedom the result is significant at 0.1%.

It is also possible to test separately the association between each of the two variables (geopedology and vegetation) and the identification of sites. This can be done by partitioning the degrees of freedom of the test above. This means performing a chi-square test for each of the two effects on site recovery using the marginals in Table 5 (Hayes, Immer, and Smith 1955).

Geopedology effect:

$$\chi^2 = \frac{(75-66.1)^2}{66.1} + \frac{(3-11.9)^2}{11.9} = 7.88$$

With one degree of freedom the value is significant, at 1%.

Vegetation effect:

$$\chi^2 = \frac{(70-36.4)^2}{36.4} + \frac{(8-41.6)^2}{41.6} = 58.11$$

With one degree of freedom the value is significant, at 0.1%.

The significance of the interaction between the two variables can now be tested subtracting the chi-square values for the two effects from the total chi-square value.

$$\chi^2 = 80.52 - 7.88 - 58.11 = 14.53$$

With one degree of freedom the value is significant, at 0.1%.

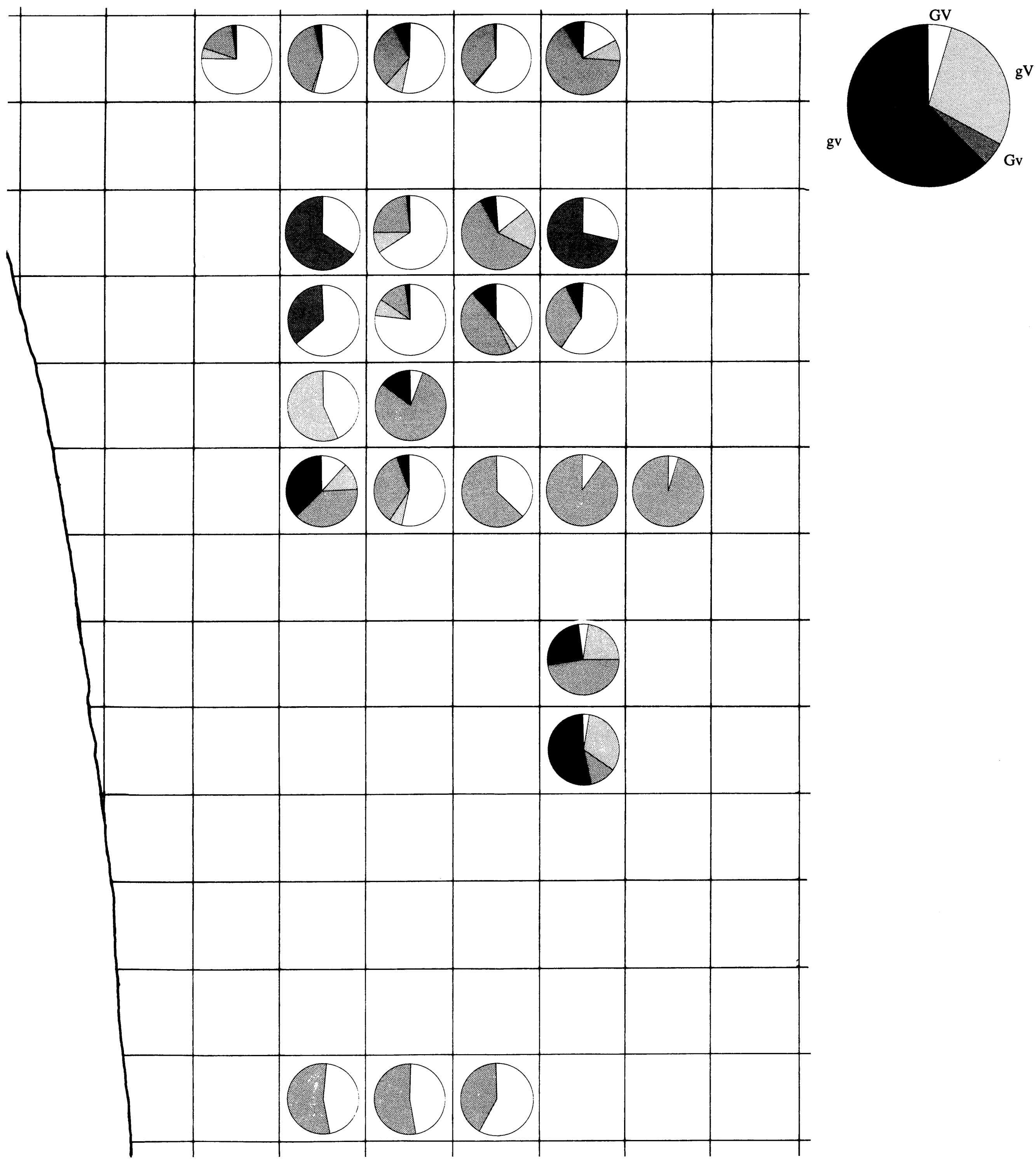


Figure 5. In this figure the small pie diagrams give the percentage of a unit's area belonging to each of the four classes (GV, gV, Gv, gv). Each pie diagram is shown at its respective position on the map. The large pie diagram represents the percentage of area belonging to each of the four classes for all 25 of the sampling units.

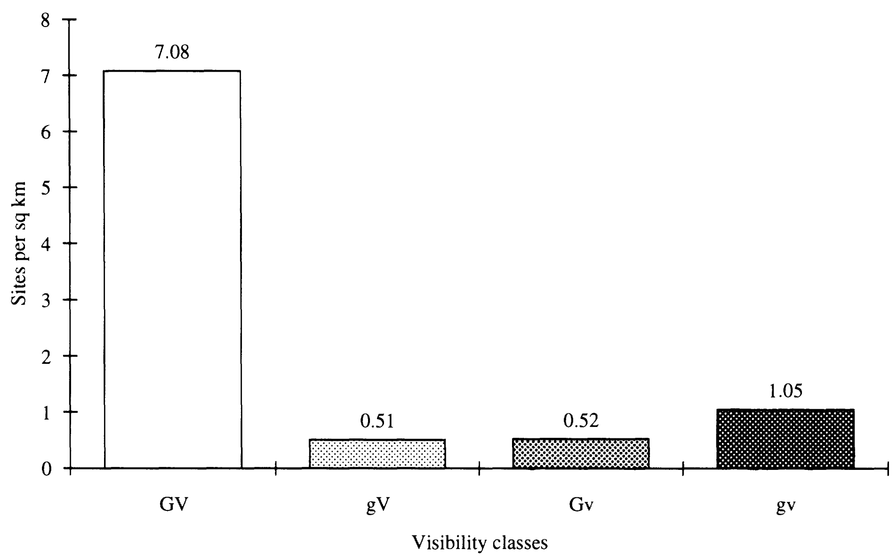
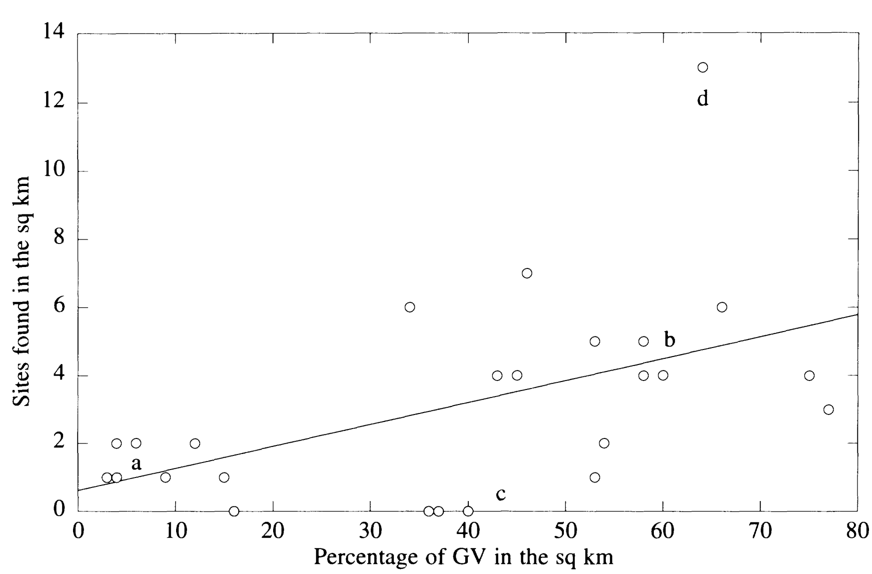


Figure 6. Bar diagram showing the density of sites per sq km for each of the four classes of visibility.

same degree of association or is there more in the way of variability between them? In order to answer this question, we performed the regression analysis shown in Figure 7. For each of the 25 km squares, the number of sites recovered is plotted against the percentage of the unit's area belonging to the first class (GV). In other words, the values for the first class are being used here as an index of visibility. While the overall trend is clear, a positive correlation between the two variables, considerable variability is also present. In fact, the correlation coefficient is comparatively low ($r = 0.54$).

One of the implications that follows from what is seen in Figure 7 is that we cannot introduce a simple procedure for correcting the number of sites in the individual units. For example, one might consider taking the number of sites recovered in a given unit and multiplying it by the inverse of its value for visibility. If the regression analysis had shown a stronger correlation coefficient, the use of

Figure 7. Graph showing the relationship between visibility (on the horizontal axis) and the number of sites (on the vertical axis) identified for each of the 25 units. The value for the best class of visibility (GV) is used as an index for visibility here. The regression line has been fitted by the least-squares method; the correlation coefficient (r) is 0.54. The four lower case letters are explained in the text.



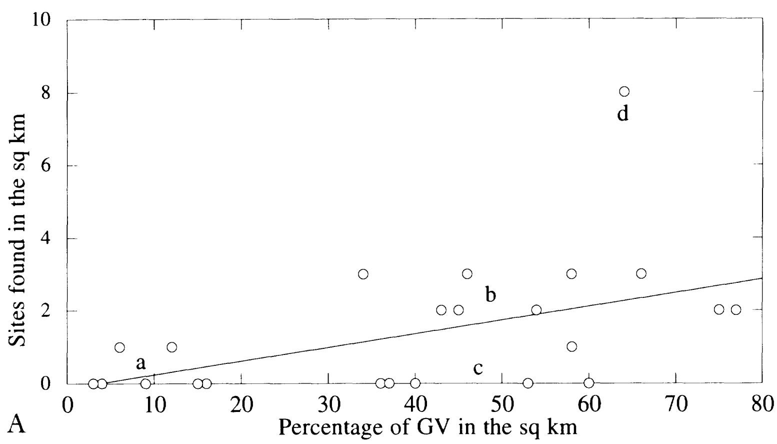


Figure 8. A) The graph shows the regression analysis (see FIG. 7) for the Hellenistic period, which has a total of 33 sites. The correlation coefficient here is 0.5. The letters are the same as those used in Figure 7. B) (Facing page) The map shows the distribution of sites dating to this period. In addition, for each unit, a letter is plotted within its respective square on the map in correspondence with the position that it has in the graph above (see the text). In order to bring out the spatial patterns the shadings used on the map are: a (no shading), c (light shading), b (medium shading), d (dark shading).

such a relatively straightforward correction would have been more appropriate. In our case, due to the variability that is observed, we will have to look more closely at the situation as it relates to each unit.

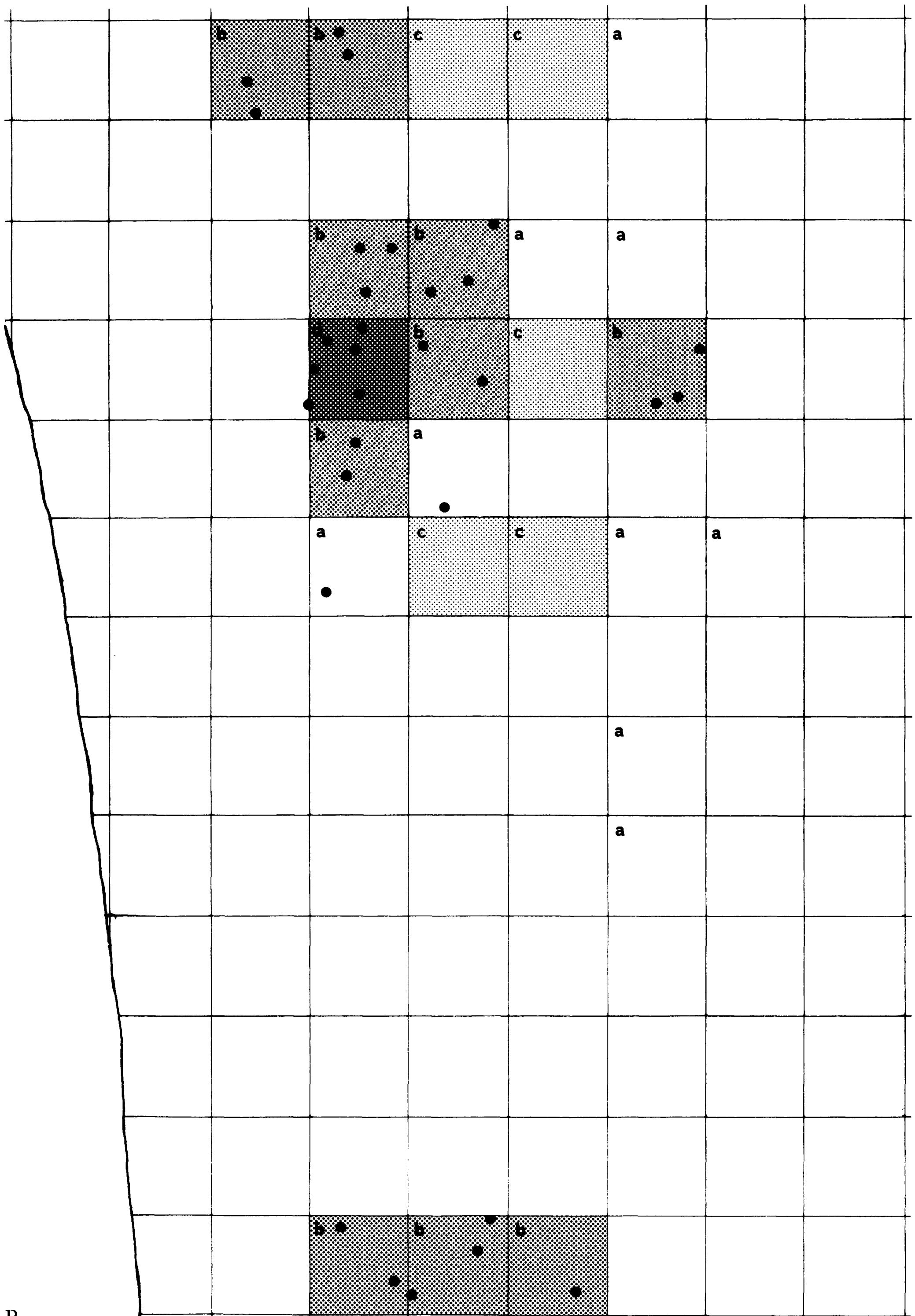
Let us return to Figure 7 and make reference to the four letters which have been placed there for purposes of discussion. Here the letter "a" would represent the case where a unit has both low visibility and very few sites and "b" that of good visibility and a fair number of sites. The points for both of these cases stand close to the regression line. In the two other cases, the points can be quite far from the regression line. Such points contribute to the low value for the correlation coefficient. In the case of c, a unit will have a good value for visibility but no sites. The fact that a sampling unit presents good visibility does not in itself guarantee that sites will be found there. Places may exist on the landscape that have experienced little or no settlement.

Alternatively, in the fourth case (d) a given place may have had either a cluster of sites or a particularly rich history of settlement. Thus, the interaction between visibility and site recovery at the local level can be quite complex.

In moving toward the interpretation of survey data, there is something else that we have to consider. Since settlement patterns can change over time, inferences, whenever possible, need to be made in the context of the individual periods. In order to illustrate briefly such an approach, we have prepared Figure 8 which gives both the regression for sites of the Hellenistic period (ca. 300–50 B.C.) and a map of the sites dating to the same phase. This is done purely for heuristic purposes; no attempt will be made to develop substantive discourse on this period here. The regression analysis shows much the same kind of results as Figure 7. Again four letters have been placed on the graph to distinguish the different cases mentioned above. For each point falling in the appropriate case the letter has been placed in its corresponding unit or square on the map.

In the interpretation of spatial patterns it is instructive to think about how we may want to read each of the four cases. If a given square on the map contains the letter "a", the lack of sites there is to be viewed as a normal consequence of its low visibility and accordingly no clear inference can be drawn, at the current state of knowledge, about the presence or absence of sites in this place. In short, there is not much being learned by the survey from those units which belong to this case. The second case, b, is a more positive one. Here a 1-km square has fair to good visibility and one or more sites will have been discovered in the unit. For such squares, even if not all of the sites dating to the Hellenistic period have been found yet, we definitely know that sites occurred in this place. When visibility is good but no sites are found in a unit, the third case (c), we are in a position to infer that there probably were no occupation sites in this place during the period in question. In the fourth case (d), a point representing a positive outlier on the regression, the unit will have many more sites than one would expect on the basis of its value for visibility.

In archaeological terms such units and their location on the map will be of particular interest, since they probably suggest local clustering in the settlement pattern. But the



B

important thing is to widen our vision beyond the individual units (and their respective letters) toward the recognition of larger patterning on the map. Thus, in formulating arguments about settlement patterns, we will have to look at a given site distribution no longer, essentially, as a thing in itself, but in the framework of the pattern of shading on the map. The shading, as a vehicle for expressing how sites found in a given unit relate to visibility, now becomes a focus of attention in its own right—one of no less interest than the site distribution itself. This means, in other words,

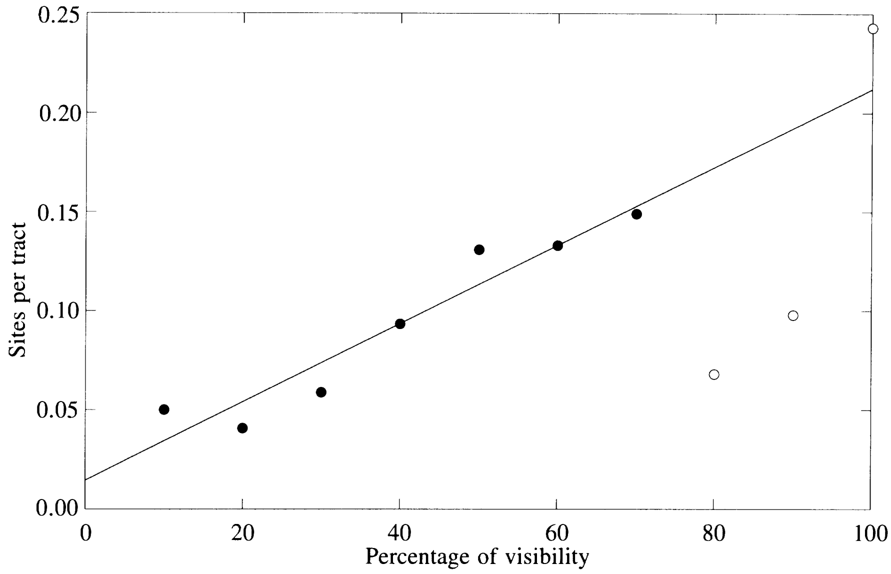


Figure 9. Graph showing the results of a reanalysis of the data presented in Cherry, Davis, and Mantzourani (1991: fig. 3.6). The horizontal axis gives the 10 classes of relative ground visibility (10% through 100%). The vertical axis gives the ratio of sites to tracts for a given class of visibility. The last three visibility classes (80% through 100%) are shown as open circles since the ratio estimates used here are based on low counts of sites and tracts. The best estimate for the slope of the regression line is given by the first seven classes which have more robust data (see note 4).

a shift toward thinking about a site distribution more in terms of the spatial context of its recovery.

Discussion

The study presented is the first one to examine in depth the issue of visibility. In the case of the Cecina Survey we can document in quantitative terms a strong relationship between surface visibility and the discovery of sites. This result has far-reaching implications for archeological surveys. This applies both to the planning and conduct of surveys and to the interpretation of survey data. It is no longer a sound practice simply to assume that the sites found during the course of survey work provide a full or adequate representation of the sites that are actually present in the area examined. As we have seen, in the case of the coastal plain at Cecina, it is reasonable to infer that only about one-half of the sites have been recovered. While survey archaeologists, at the level of everyday experience, have felt for some time that visibility was a problem, no sustained attempt has previously been made to measure the scale of its impact.

What is obviously needed over the long run will be more case studies of the kind presented here, thus making it possible to evaluate the role of visibility in a wider range of survey contexts. At the present time, there is one other survey in the literature which throws direct light on the issue, and that is one carried out on the Aegean island of Keos (Cherry, Davis, and Mantzourani 1991). By reworking the data that they present in fig. 3.6 of their monograph (see Ammerman 1993) it is possible to obtain the regression shown in Figure 9. Here one again sees a clear relationship between visibility (that is, observations made on individual survey tracts and grouped here as in fig. 3.6 according to 10% intervals) and the ratio of sites found per tract for the respective visibility intervals.[4] To put this graph in plain words, what the regression line means is that when visibility is at the 70% level one will have to look at six tracts, on average, in order to find a site on Keos.

In contrast, when visibility is 30% or less, there will be a

4. In their own evaluation of the relationship between visibility (based only on ground cover) and site recovery Cherry, Davis, and Mantzourani performed a Kolmogorov-Smirnov nonparametric test and concluded that there is "a tendency for the artifact concentrations we have treated as sites to lie in tracts whose visibility is distinctly better than average" (1991: 42). In other words, they found a positive association between visibility and site identification. In the reanalysis presented in Figure 9 we are particularly interested in the slope of the regression line. Since the last three classes together contain only about 6.5% of the tracts (with the highest one having just 3%), these classes have been excluded from our statistical analysis (see open circles in Figure 9). On the basis of the first seven classes the r value is 0.95 and the slope the regression line is 0.0019. An alternative treatment would be to lump the values for the last three classes (80%, 90%, 100%) together and to display them as a class corresponding in its position to 90% on the horizontal axis. In this case the correlation coefficient would be $r=0.78$ and the slope of the line 0.0012. Note that since visibility was monitored only in terms of ground cover on Keos, the values recorded are probably inflated (not taking geomorphology into account). This is especially so for the highest classes.

need, again on average, to examine 20 or more tracts in order to recognize a site. If further case studies continue to show the kind of relationship found at Cecina and on Keos, it will be necessary to make major changes in survey methodology. In any survey, in trying to operationalize surface visibility, much will depend on the resources available to the project. For example, if one decides to record ground cover on a field-by-field basis, at the time when an area is surveyed, it will be of the essence to have maps that show field boundaries in some detail. In our own case, we were fortunate to have access to a series of cadastral maps; it will be much more difficult to map ground cover in those parts of the world where maps of this kind are not available. At Cecina we also had the favorable situation wherein the geomorphology of the coastal plain, recently mapped by Mazzanti (1986), could be treated in terms of a simple two-way classification. One can think of other cases where patterns of geomorphology will be more complex; indeed, this happens to be the situation in some of the interior parts of the Cecina Valley.

Another advantage that we have in the present study is that the sites, the targets of discovery, are of comparatively recent archeological age. In those cases where the primary interest is in sites of earlier age, a more sophisticated strategy may be required in order to deal with the problem of visibility (see, for example, the approach in Ammerman 1985a). In practical terms, in any given survey, the challenge that the team of archeologists may well have to face is that of fitting the limited resources available to the specific character of the local situation.

The results at Cecina also imply certain changes in our approach to the interpretation of survey data. A discovered-site distribution is only one part of a settlement pattern. As we have seen above, corrections will have to be introduced if we are to make realistic statements about such things as the number of sites that once existed in an area and their density on the landscape. Both of these will be underestimated if the site distribution for a given period is assumed to be equivalent to its settlement pattern. The opposite will be true for the distances between sites. If the situations at Cecina and Keos are indicative of surveys in general, this places in jeopardy the interpretative accounts in much of the survey literature, where the optimistic assumption of equivalence is made. For such surveys there is no easy way to develop, in retrospect, a correction for visibility. The main reason for this is that the landscape at the time of recovery, especially with regard to ground cover, cannot be revisited. Indeed, in many parts of the Mediterranean world, patterns of modern land use themselves are subject to dynamic changes (Ammerman 1995).

One possible way out of this dilemma is to think that one can at least trace changes in settlement patterns between periods, by first taking the more realistic view that site distributions are incomplete, and then making the assumption that visibility operates uniformly with respect to the site distribution of the various periods. The problem here is that one wants to study something that is changing in space over time and yet visibility, at least as seen at Cecina (recall FIG. 7), exhibits marked variability in space. In other words, the working assumption of uniformity cannot be sustained. Thus, the mere acceptance of the incompleteness of site distributions does not in itself resolve the matter of the interpretation for those interested in the study of settlement patterns as long-term history.

In contrast with surveys already in the literature, the prospects are potentially more promising for a survey that is still in progress (or even better for one just being planned). There will be an opportunity to try to put an evaluation of visibility in place, and this may well lead to corrections of the kind needed for the analysis and interpretation of survey data. While the exact form that such corrections will take and the strategies for their implementation will no doubt vary from one survey to the next, there are two general considerations that we may want to bear in mind.

The first is that in making inferences about a region as a whole, greater weight should be given to what is found in the better known parts of the survey area—namely, those offering higher visibility. The second concerns more specifically the analysis and interpretation of spatial patterns. The central problem here is how to deal with those places on the map that have little or no surface visibility. One strategy to consider here will involve trying to recycle information from adjacent places that are better known. This is the kind of approach that we are moving toward in Figure 8, for example.

It is, of course, still too early to know which strategy or strategies will work best for purposes of spatial analysis. We are still at an early stage of the interpretation of site distributions in the context of visibility. In conclusion, it is our view that the treatment of this factor should become a standard feature of surveys in archaeology. It is now time to turn our concerted attention to working out adequate methods for coping with the fundamental problem of visibility in surveys.

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