15. Diodorus Siculus and the island of Hvar, Dalmatia: testing the text with GIS

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15.1 Introduction

> 'In the end, what ancient historians now require of archaeologists is something much simpler, much more primitive — a willingness to devote themselves to precisely formulated historical questions and a far greater consciousness of the value of statistics, for which pencil and paper and elementary numeracy are on the whole sufficient, though a simple computer would do no harm,' (Sir Moses Finley, *Archaeology and History*, reprinted in *The Use and Abuse of History*, 1986:99).

Given that the paper in which the above quote originally appeared was published twenty years ago, it would be unfair to present the statement as wholly representative of the contemporary relationship between ancient history, archaeology and computer science. However, the interaction between the three disciplines is still a subject of discussion and debate (Yorston 1987) and much remains to be said on the subject. In this short paper we wish to discuss the archaeological context of one particular historical event, the colonisation of the Island of Hvar by the Parian Greeks in 385/4 B.C. and its violent aftermath. The circumstances surrounding these events were conveniently, if belatedly, chronicled by the historian Diodorus Siculus in the first century B.C. and the broad outline has been confirmed by later work. But is this broad agreement enough? Diodorus, in common with other classical sources tells us little about the political and economic situation on the island preceding the arrival of the Greeks. Consequently, the text has many limitations, even by historical standards. Some further insight into these problems has resulted from a recent survey of the archaeological sites of the island (Gaffney *et al.* in prep). More significant is the recent development of GIS technology and its increasing application to archaeological data in general, and to the Hvar data in particular (Gaffney & Stančić 1991). The flexibility of analysis that GIS is opening to archaeologists is rapidly revolutionising archaeological research. This has implications that ancient historians cannot ignore. Events and processes occur in both space and time, concepts common to both historians and archaeologists. GIS allows a manipulation of space that has previously never been practicable. The relevance of these statements will, we hope, become clear within the paper.

15.2 The Island of Hvar

Before presenting the analysis, some introduction to the island of Hvar is useful. The island lies off the coast of central Dalmatia, Yugoslavia (Fig. 15.1). At the nearest point the island is only 4km from the mainland. It is about 68km long and nowhere exceeds 15km in width. The long, narrow shape of the island is dominated by a high mountainous spine which is topped over the most part by a bevelled plain at about 300m, but rises to 626m at the highest peak named Sv. Nikola. The coastline is precipitous but the northern central section is dominated by the low, fertile Stari Grad plain.

The dominant limestone geology of the island has produced typical karst scenery. Steep slopes and caves abound, the soils are generally terra rossa variants and the Mediterranean vegetation is characterised by pine forests on the steeper slopes, whilst olives, vines,

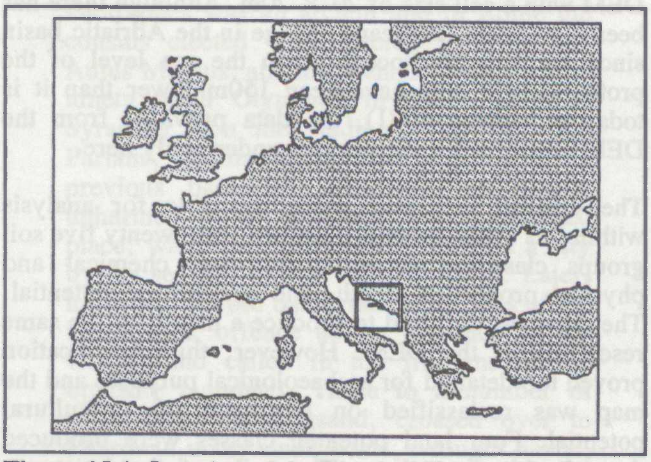


Figure 15.1: Location of the Island of Hvar within Europe.

lavender and rosemary dominate the lower and flatter areas. The climate of Hvar is particularly pleasant and the population of the island is now largely devoted to catering for the tourists that flock there during the summer months. The island of about 11,000 people, is largely found in three coastal settlements; Hvar, Stari Grad and Jelsa. The rest are scattered throughout the small inland villages (Fig. 15.2).

15.3 Data used in the analysis

A complete survey of archaeological monuments on the island was undertaken between 1982–1989. This survey provided standardised data on every monument on the island dating from the prehistoric, Greek and Roman periods. During those years, all the locatable archaeological monuments on the island were visited and all available material on them collated. This information was put into a database which could be used in conjunction with the island's environmental database for a GIS analysis.

Three principal environmental variables were used with the archaeological database. The first variable, topography, involved the creation of the island DEM

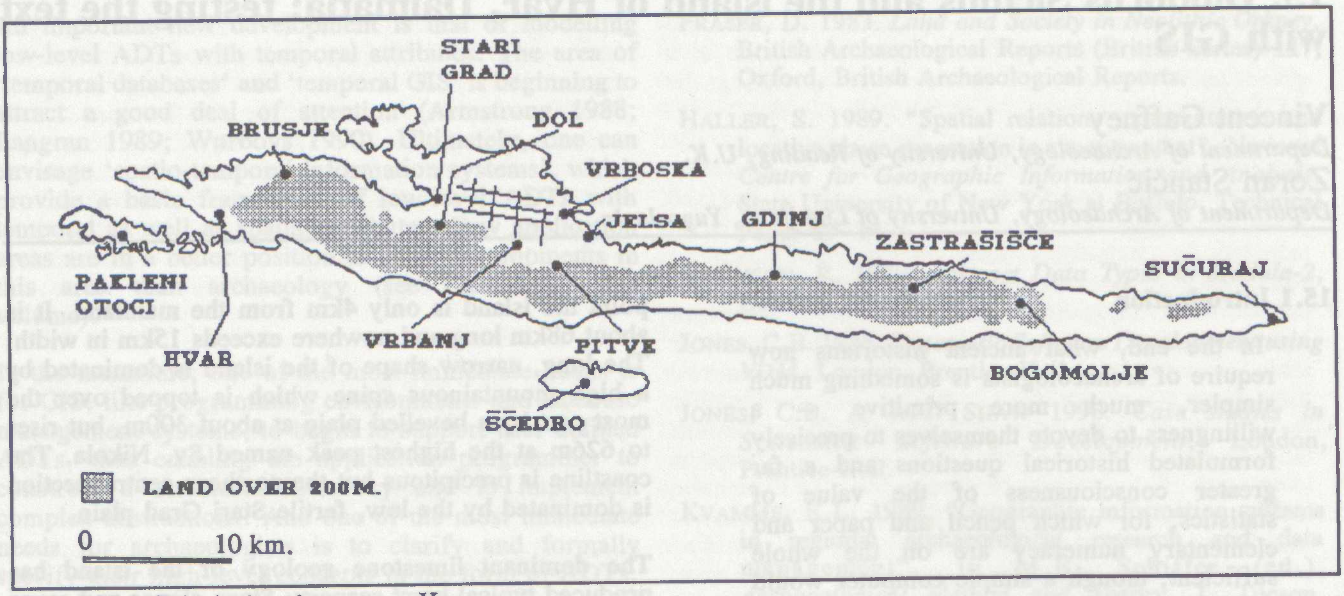


Figure 15.2: Principal settlements on Hvar.

from the 1:50,000 topographic map. This produced a DEM with a cell size of 20 × 20m. Although there has been significant landscape change in the Adriatic basin since the late Pleistocene when the sea level of the proto-Adriatic may have been 150m lower than it is today (Chapman 1981), the data provided from the DEM is useful for the periods under study here.

The detailed soil map made available for analysis within this study contained no less than twenty five soil groups classified according to their chemical and physical properties, depth, and agricultural potential. The data was digitised to produce a map with the same resolution as the DEM. However, this classification proved too detailed for archaeological purposes and the map was reclassified on the basis of agricultural potential. Four land potential classes were produced through this procedure. The soils of the karst are distressingly fragile and prone to erosion and significant changes can occur during very short periods of time. Soil change over time has undoubtedly been dramatic (Shiel & Chapman 1988). Many areas which now have limited agricultural potential must have been more attractive to human use in the past, and some areas which may not have been so useful, e.g. seasonally flooded valley bottoms, may now have been modified to form attractive agricultural zones. For the purposes of this study, however, we are reliant upon contemporary data and the belief that the soils which are considered useful today also played a significant role in earlier agriculture regimes.

Lithology is undoubtedly the most stable of environmental factors used in this analysis. The basic solid geology of the island has remained unchanged throughout the period under study (Herak *et al.* 1976). The island is dominated by a core of dolomite and limestone laid down during the Cretaceous, overthrust and raised during later orogenies. The archaeologically important flysch deposits on the southern side of the island are Eocene in date, whilst Quaternary deposits including alluvium and colluvium are restricted, mainly to the Stari Grad plain and the narrow coastal valleys.

15.4 Hardware and software used in the analysis

The data presented here was taken from a larger GIS pilot study carried out using equipment belonging to the Arkansas Archaeological Survey (AAS) at the University of Arkansas. The GIS system used by the AAS and which was made available for this work is the Geographical Resource Analysis Support System (GRASS).

GRASS was designed as a high performance interactive environment for geographic data management, analysis and display. It was originally created for the US Army and was intended to be applied in land management programs associated with military installations. Its primary aim is to allow the optimal use of available training areas and ranges, to maintain land in a manner suitable for long term military use whilst protecting valuable natural and cultural resources and accommodating secondary land uses including forestry, grazing, hunting and recreation (Lozar & Goran 1987).

The origins of GRASS lie in the use of raster based software in the analysis of the Fort Hood area in Texas. GRASS itself, however, has only been available since 1986 and is still undergoing development (Westervelt 1988). Despite this, the software has now been released into the public domain and it can be obtained without cost from the Army Corps of Engineers, Construction Engineering Research Laboratory and a number of associated federal agencies. Many public domain software suffers from poor documentation and a lack of consistent development funding, training opportunities and system support. However, this is offset for GRASS by the fact that the number of GRASS users within the US establishment virtually ensures continuing development of the system and the fact that some private companies and universities are now distributing GRASS commercially and will assist with training and installation of the system.

GRASS is a UNIX based software written in C. It is distributed in source code and is currently running on a number of different workstations including; Sun, Concurrent, Intergraph, Apple Macintosh, PC386 and 486's, HP9000, AT&T 3B2, DEC, and IBM 6000. It has recently been released in the X-Windows environment increasing its portability to any machine running under such an environment (Gardels 1988; Westervelt 1990). GRASS allows the user to manipulate, analyse and display data, and output data as colour images or in tabular statistical form. It allows digitisation of data layers manually through a digitising table or alternatively to input data in digital format either as a DEM, digitised aerial photographs or satellite data including SPOT or LANDSAT. Inputted images can be processed using a variety of filters and spatially located and analysed via multispectral classification (Madry 1989). GRASS contains modules for the analysis of watersheds, drainage networks, visibility analyses and least cost surfaces and paths. Boolean and weighted analyses can be carried out along with distance measurements from points, lines and polygons. Powerful modules for univariate statistics are also included within GRASS. Modules exist allowing GRASS to communicate with other GIS packages. The integration of GRASS with some specific database management systems and statistical packages allows the retrieval and interactive manipulation of data from relational databases and the performance of sophisticated multivariate analysis (Farley 1989; Parker 1989).

Several different hardware platforms were used during this study. A Compaq 386 PC with Altec digitiser was used for data input whilst Masscomp and Concurrent machines with larger monitors with greater resolution were used for analysis. Inkjet and thermal printers provided hardcopy output. The performance of GRASS on these different units was essentially the same, the only difference occurring as a result of the mass storage units and the processing speed. In this respect the Masscomp was a relatively poor performer. Given the resolution of the raster data, nearly 4 million 20 × 20m cells per data layer, the greater speed of the newer machines was of great value.

15.5 The archaeology of Hvar

The history of the island and its archaeological remains are a fascinating study. Finds of impressed ware sherds from a number of cave sites on the island indicate human habitation on the island about 7,000 years ago. Grga Novak's definition of the later Neolithic Hvar culture, based on the discovery of the distinctive and rather beautiful painted pottery in cave sites, especially, Grabceva and Markova Spilja, on the island brought Hvar to the attention of many archaeologists (Novak 1955, 1959).

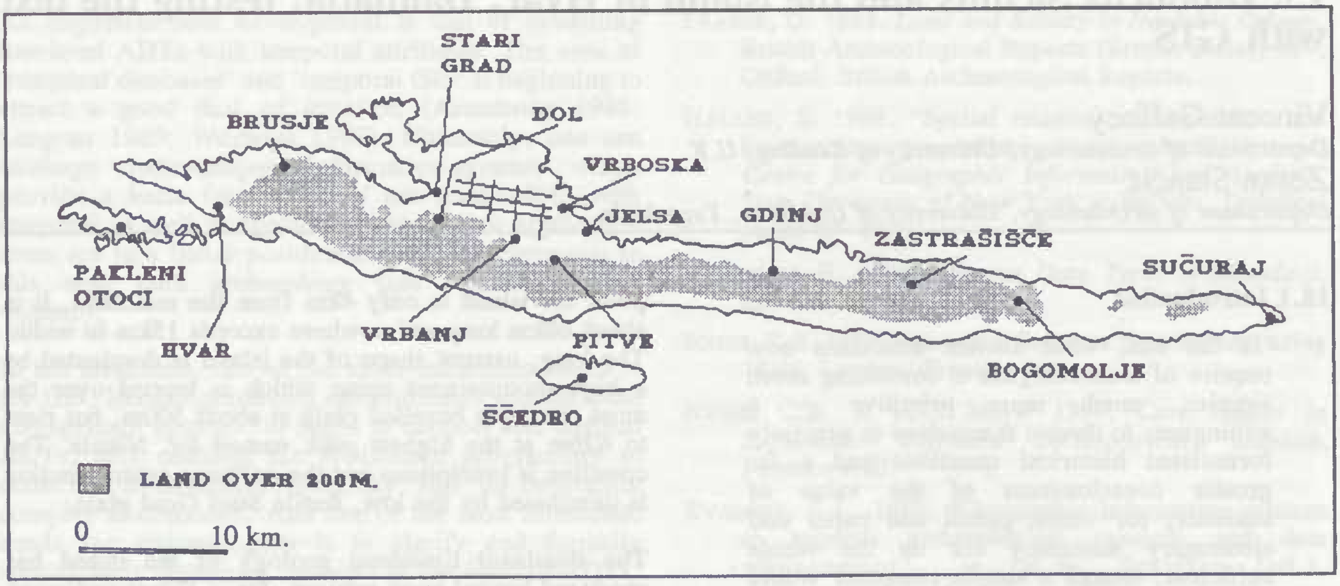
The Bronze Age is characterised by the large numbers of burial mounds found on the island (Petrić 1979; Marović 1985). These mounds number hundreds throughout the island as isolated examples or in groups several of which may be classified as cemeteries. Within these cairns, the most frequent burial practice is that of a crouched burial within a rectangular stone cist. Although some of these mounds achieve massive proportions, up to four metres high and thirty metres in diameter, grave goods tend to be relatively poor and restricted to pottery and occasional metal and stone objects. There are also some indications of human settlement on hilltop sites across the island.

During the Iron Age there is increasing evidence for intensive settlement activity throughout the island and for some degree of settlement hierarchy. The Hvar castle site, which is associated with the large barrow cemetery at Vira, is of particular interest. Apullian pottery from this site indicates the incorporation of the island within long distance trade networks from the eighth century B.C. onwards (Petrić 1986).

The Greeks were becoming increasingly interested in the Adriatic from the eighth/seventh centuries B.C. onwards (Batović 1984). Presumably, the Greeks were attracted to this area initially by the prospect of trade with the peoples who inhabited the islands and the shores of the Eastern Adriatic. Trade turned to settlement in 385/4 B.C. when we learn from the first century historian Diodorus Siculus that the Parian Greeks decided (on the advice of an oracle) to found a colony on the island of Hvar.

> 'At the conclusion of the year, in Athens Diotrephes was an archon and in Rome the consuls elected were Lucius Valerius and Aulus Mallius, and the Eleians celebrated the ninety ninth Olympiad in which Dion of Syracuse won the stadion. This year the Parians, who had settled Pharos, allowed the previous barbarian inhabitants to remain unharmed in an exceedingly well fortified place, while they themselves founded a city by the sea and built a wall around it. Later, however, the old barbarian inhabitants of the island took offence at the presence of the Greeks and called in the Illyrians of the opposite mainland. These to a number of more than ten thousand, crossed over to Pharos in many small boats, wrought havoc, and slew many Greeks. But the Governor of Lissus appointed by Dionysius sailed with a good number of triremes against the light craft of the Illyrians sinking some and capturing others, and slew more than five thousand of the barbarians, while taking some two thousand captive,' (Diodorus Siculus XV, 14).

The remains of this colony, which was known as Pharos, can still be seen on the site of the modern town of Stari Grad. Some sections of its defensive wall of the colony still stand to several metres in height, whilst excavation on the site has provided traces of classical and hellenistic houses (Kovačić 1989). The colony is associated with a massive field system which appears to have been laid out in a single phase (Stančič & Slapšak 1988). The traces of these fields stretch across the Stari Grad plain, the largest fertile area on the island, from Stari Grad in the West to Vrboska in the East and cover an area of about twelve square kilometres. The boundaries of the fields have been preserved in massive field walls constructed from stones collected during field clearance and it is one of the best preserved examples of such a field system. The town of Pharos and its territory were protected at one point by a pair of large stone towers at Maslinovik (Kirigin & Popović



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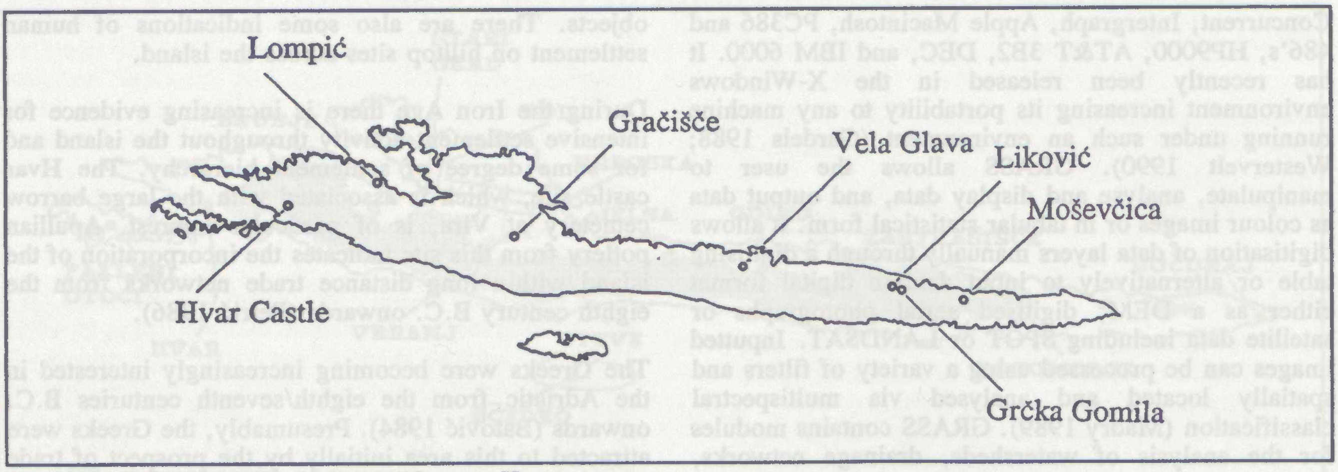


Figure 15.3: Position of principal hillforts on Hvar.

1988) and Tor (Zaninović 1982). Whilst the tower of Maslinovik has suffered extensive damage, that of Tor has suffered less, presumably because of its isolated position high above the plain of Jelsa.

15.6 Diodorus Siculus and Hvar

The situation outlined by Diodorus Siculus with respect to the Greek colony on Hvar is relatively clear. The Greeks, after coming to some sort of an agreement with the native Illyrians are allowed to plant a colony on the island. For reasons which are not explained to us, the two communities come into conflict and the Greeks were attacked. The colonists were hard pressed by the islanders and their Illyrian allies, however, the lieutenant of Dionysius the Elder of Syracuse arrives with help from either Lissus in Albania or Issa on the near by island of Vis (Wilkes 1969:9–10). The ensuing conquest left the Greeks as clear victors.

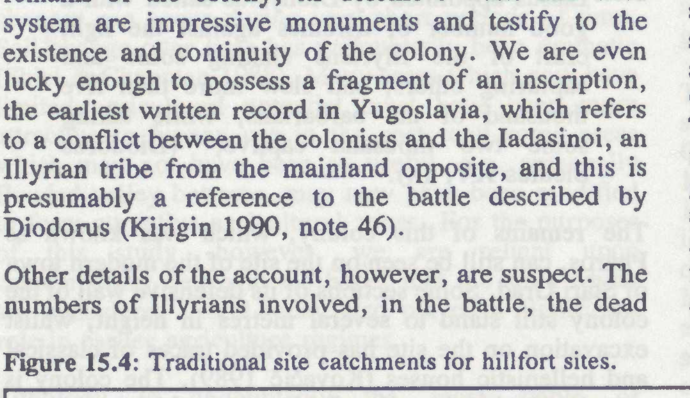
But just how accurate was this description of the events and their aftermath. The basic details of the founding of Pharos can be substantiated. The archaeological remains of the colony, its defensive walls and field system are impressive monuments and testify to the existence and continuity of the colony. We are even lucky enough to possess a fragment of an inscription, the earliest written record in Yugoslavia, which refers to a conflict between the colonists and the Iadasinoi, an Illyrian tribe from the mainland opposite, and this is presumably a reference to the battle described by Diodorus (Kirigin 1990, note 46).

Other details of the account, however, are suspect. The numbers of Illyrians involved, in the battle, the dead and the enslaved are obviously an exaggeration, resulting, perhaps, from Diodorus' desire to enhance the achievements of the Greeks. If we discount Diodorus' figures, the historian was, after all, writing several centuries after the events and true quantitative history was never an aim of Greek and Roman historians, the plain implication of the text remains that the Greeks won an overwhelming victory.

We can go some way to testing this assertion by reconstructing the demographic and political situation on the island at the onset of Greek colonisation and analysing the effect of the arrival of the colony upon this situation.

Iron Age settlement sites on the island are mainly represented by defended hilltop sites which are surrounded by stone ramparts, some of which can achieve massive proportions. The majority of these sites can be classified as lower ranking settlements which amount to little more than a wall defending a small hilltop spur upon which a few huts can be built with some degree of security. However, a small group of sites stand apart from the majority by virtue of their size, and these appear to represent the top of the settlement hierarchy. The hillfort sites within this group are those at Moševčica, Liković, Grčka Gomila, Vela Glava, Gračišće, Lompić, and Hvar Castle (Fig. 15.3). These hillforts could have accommodated larger numbers of inhabitants and their defences indicate a greater control and investment of labour. We can assume that the existence of these sites indicates the ascendance of some social groups and that the sites functioned as some form of political/economic centre and central place. We may also suggest that these

Figure 15.4: Traditional site catchments for hillfort sites.



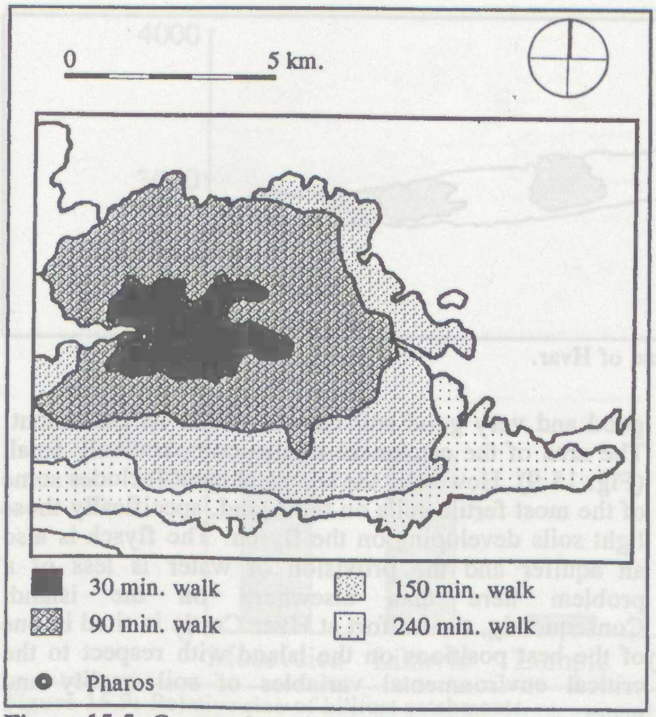


Figure 15.5: Cost surface across the Stari Grad plain.

societies were agriculturally based and that the sites were placed both for defensive purposes and to allow access to agricultural resources. Information on the economic territories of these sites prior to the arrival of the Greeks therefore provides an insight into the critical economic basis of these communities.

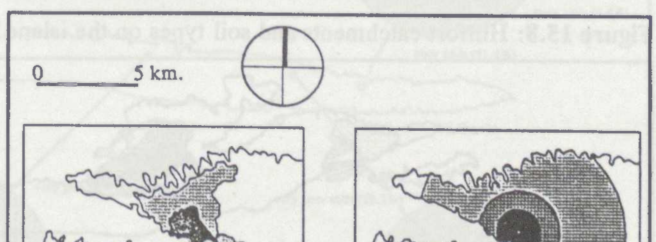
Traditionally this information is supplied by constructing catchments around these seven sites by simply imposing a series of circles with 1, 2 and 5km radius' centred on each hillfort. The result of this simple operation can be seen in Fig. 15.4. This illustration clearly shows a considerable degree of overlapping of catchments. This overlap is largely the result of the naive application of simple catchments without reference to the energy cost of moving across the notoriously difficult karst surface. However in the case of Liković and Grčka Gomila, sites which are placed on adjoining spurs, other archaeological considerations led us to decide to exclude the latter site from the analysis. The position of these hillforts is rather curious. It is unlikely that two such aggressive communities could have existed at such a close proximity. It is, of course, possible that the two sites are not contemporary and that only one was in use at any one time. An alternative possibility is that Grčka Gomila is not a settlement site. Survey of this site indicated that despite the massive nature of the ramparts (they are at one point more than 6 metres in height), they did not appear to be fulfilling an efficient defensive role. The largest rampart is facing, at a very short distance, a small hill of the same height. Similar situations have been recorded for hillforts in Britain where it has been suggested that some of the sites may have had a ritual, rather than defensive role (Bowden & McOmish 1987, 1989). We therefore decided to exclude Grčka Gomila from the analysis.

Despite removing Grčka Gomila from the sample, some degree of territorial overlap still remained. We overcame this problem by using GIS to replace the simple catchments with ones derived from a cost-surface analysis. The cost surface shows the relative energy consumption expended when an individual crosses from one point to another. We can refine this further through our knowledge of the island and by using a measured time for walking across the 5km of the Stari Grad plain as the basis for the construction of the hillfort catchments (Fig. 15.5). The same energy requirement for walking 5km on the plain will produce a different catchment for each site depending on the surrounding topography. If the land crossed is steep in one direction, the energy use will be greater and the distance to the edge of the catchment shorter. If the land in another direction is relatively flatter, this will be reflected by a longer distance to the edge of the catchment. In considering these results we should note some problems that may arise from the decision to use the distance covered by the energy cost of a walk of 5km as the basis for analysis. A walk of this distance amounts to a projected time of about 90 minutes. This time falls in between the estimated boundary for sedentary agricultural communities at 1 hour and that of herding/hunting communities at 2 hours (Bintliff 1977:112). Consequently, there is a possibility that we might be over-estimating the size of the catchments.

Despite these possible problems, in Fig. 15.6 we can see the difference between a simple catchment for the Hvar Castle hillfort site and one derived from the cost surface. Here the catchment is quite severely curtailed both by the coastline and the difficult countryside to the West and East. Significantly longer distances to the edge of the catchment can be seen to the South East where an area of flysch outcrops and provides a smoother landscape with relatively easier access and the area to the north where the route of the modern road leads to an upland plain around the village of Brusje.

The boundaries for all the six sites now being used in the analysis are easily calculated and superimposed on the outline of the map of Hvar (Fig. 15.7). It is satisfying to note that the catchments shown in this figure are almost completely mutually exclusive. The catchment at Lompić is suspiciously small — a point which will be returned to later. Having constructed these catchments the GIS software can then be used interactively to examine the environment within the catchment boundaries. Fig. 15.8 shows how we can impose the information we have on soils within the catchments.

Figure 15.6: Traditional and GIS derived catchments for the Hvar Castle hillfort



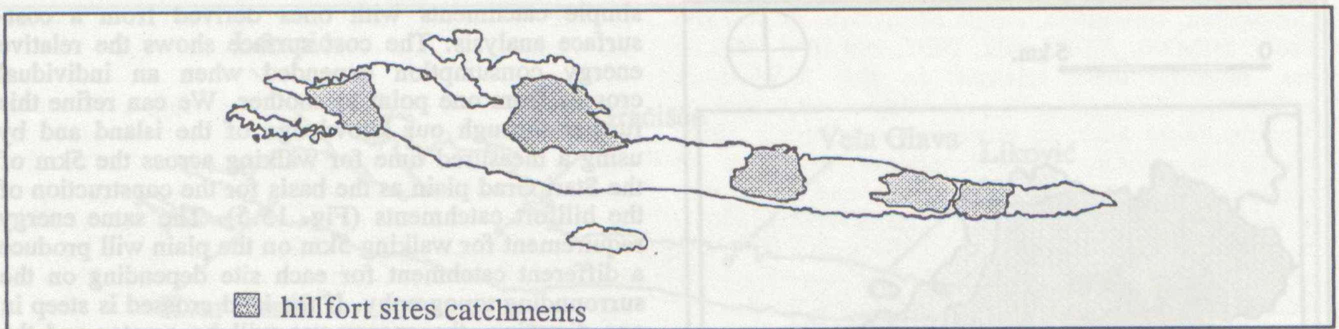


Figure 15.7: GIS catchments for major hillfort sites on the island of Hvar.

The statistical modules built into most forms of GIS can be used to analyse the varying proportions of environmental variables held within these catchments. At the simplest level we can calculate the area of the catchments, this information is shown in histogram form in Fig. 15.9. We can also confirm the presumed association between hillfort sites and control of good arable land simply by quantifying the percentages of different land classes within a catchment and comparing the results with proportions available for the whole island (Table 15.1 and Fig. 15.10).

Soil Type	Percentage of Island
Very good	20.97
Good	18.91
Poor	30.62
Very Poor	29.27

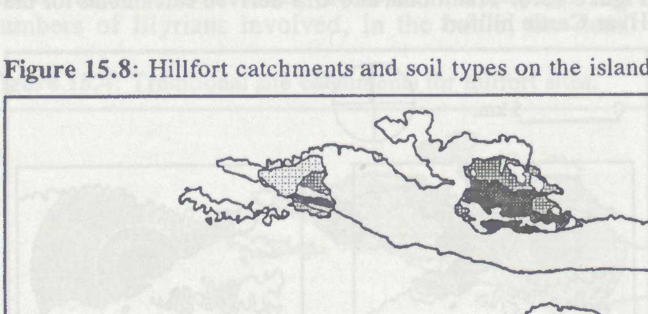
Table 15.1: Quantified soil data for the whole island of Hvar.

If the sites are situated to control the best land we would expect that there would be proportionately more of the best land within the catchment. In Table 15.1 we can see that the two best classes of land cover about 40% of the surface area of the island with the top class covering about 21%. The sites at Liković (64.5%), Vela Glava (51.2%) and Gračišće (72.5%) show a distinctly larger proportion of better and good land within their catchment than we would on comparison with the island as a whole. Moševčica (38.3%) has slightly less than we might expect. However, the quantity of very good land (34.7%) is rather more than we might have expected, and this probably explains the siting of the hillfort. The site of Hvar Castle would also appear to be an anomaly. It contains only 26.5% of good and very good soil classes within its catchment. The area of the catchment is also comparatively small (Fig. 15.9). However, the site catchment includes some of the most fertile soils on the island, specifically those light soils developing on the flysch. The flysch is also an aquifer and the provision of water is less of a problem here than elsewhere on the island. Consequently, the hillfort at Hvar Castle is sited in one of the best positions on the island with respect to the critical environmental variables of soil quality and water.

Lompić, however, is an anomaly. We have already noted above that the site's catchment was curiously small. The data on soils clearly indicates that the reasons for the positioning of this site were not agricultural. Even though a visit to the site indicates that a few of the nearby bays could have maintained some fields, they are negligible in comparison with the catchments of the other hillforts. Given our knowledge of the archaeology of the island and the position of the site we can suggest with some confidence that Lompić was located to observe activity in the Stari Grad bay, and was perhaps an outpost of the settlement in Hvar.

The strong association of these sites, with the exception of Lompić, with good soils demonstrated above is clearly shown by inspection of the illustration comparing sites and their catchments with soil types in Fig. 15.8. However, although all major hillfort sites are associated with large blocks of good land there still remain several areas of good land which do not have an associated site. These include the areas to the north-east of Hvar, that between Vela Glava and Liković and the area around Sućuraj on the extreme Eastern end of the island.

Figure 15.8: Hillfort catchments and soil types on the island of Hvar.



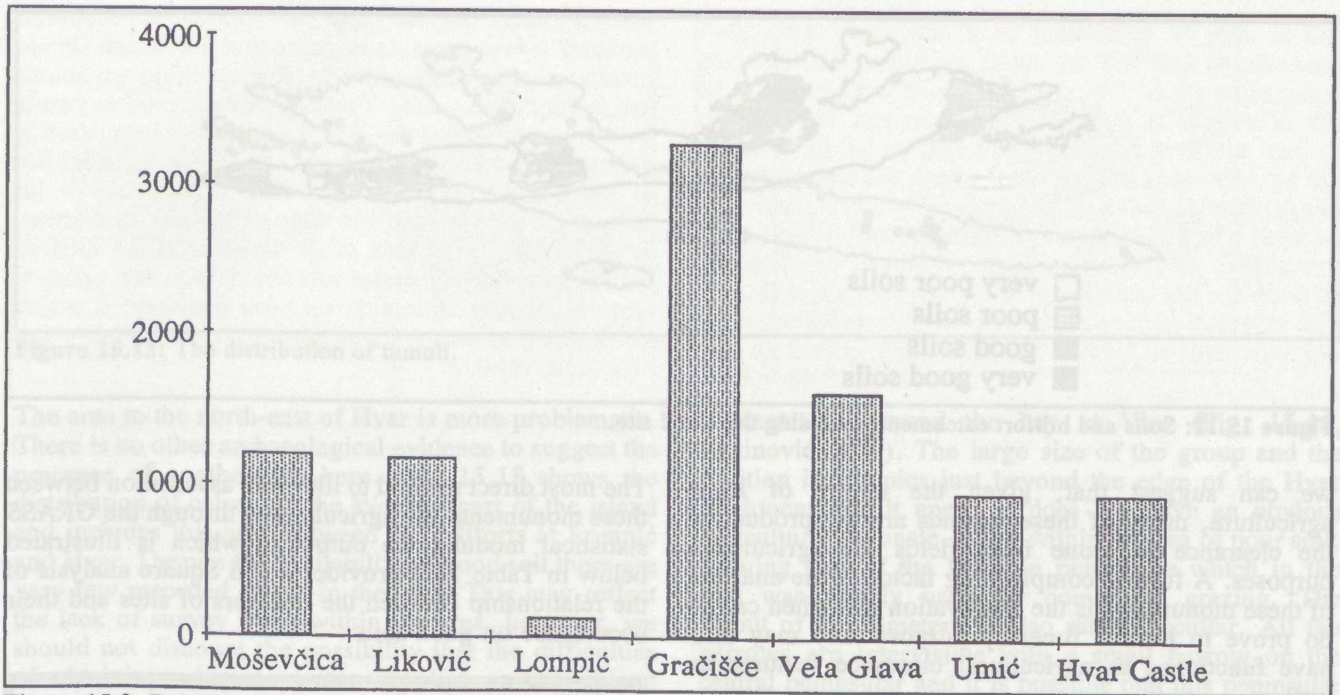
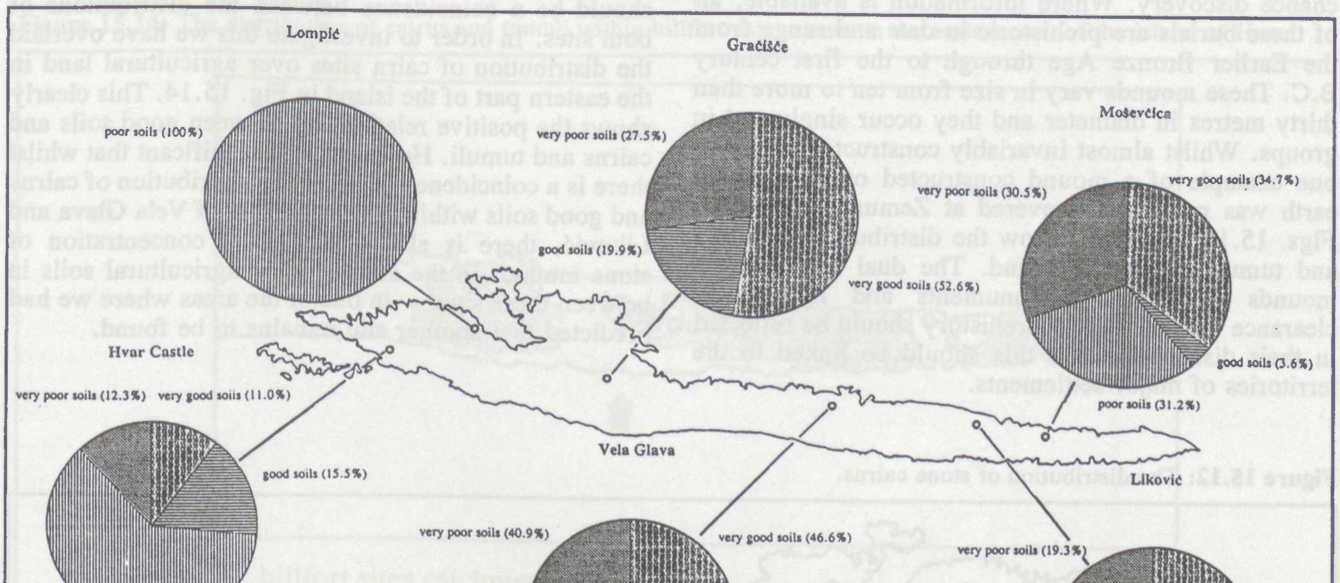


Figure 15.9: Relative size of hillfort catchments.

These gaps in the pattern may indicate that some sites remain to be discovered in these areas. Recent work by a local archaeologist in the area around Sucuraj suggests that one of the missing settlements may have existed at a site called Umić. Here the construction of a water reservoir unearthed considerable quantities of prehistoric pottery. On the assumption that this represents one of the missing settlements we have redrawn the catchment/environmental variable maps to include Umić in Fig. 15.11.

There is also further compelling evidence in the distribution of cairns that suggests the area between Liković and Vela Glava might contain another site. Stone cairns are by far the most numerous archaeological monument type on the Dalmatian karst. Despite this, the study of these mounds is a problematic issue in Yugoslav archaeology. In the past, these large prominent piles of stone have almost universally been classified by archaeologists as funerary monuments, despite the fact that upon excavation only 50% may actually contain any form of burial (Chapman *et al.* 1987:126). When these mounds are found to be empty

Figure 15.10: Soil types within hillfort catchments illustrated as pie charts.



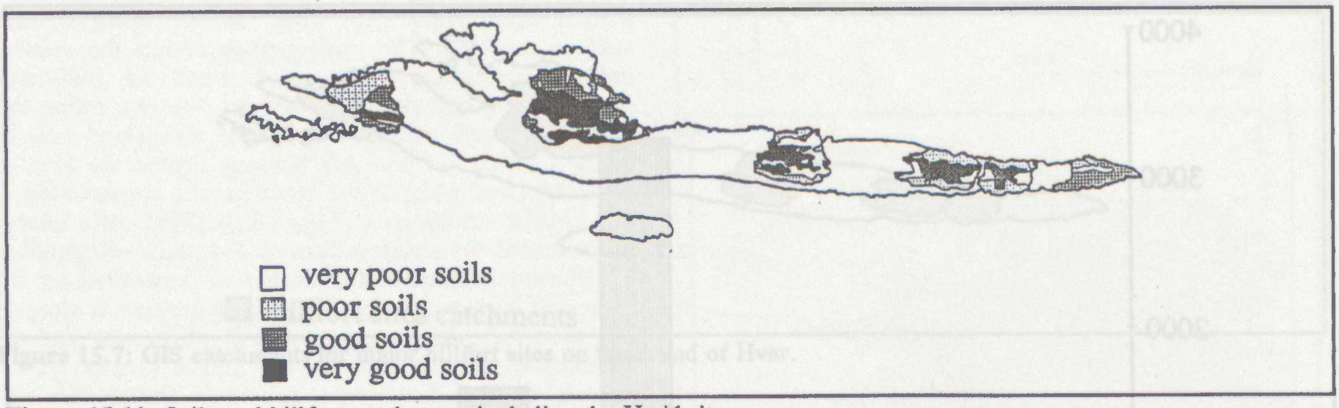


Figure 15.11: Soils and hillfort catchments including the Umić site.

we can suggest that, given the nature of karst agriculture, many of these mounds are the product of the clearance of stone from fields for agricultural purposes. A further complicating factor in the analysis of these monuments is the observation that when cairns do prove to have a funerary purpose they may also have functioned as agricultural clearance features as well.

There are nearly two hundred mounds of presumed ancient date scattered around the Island of Hvar. The actual number is probably many times greater than this. Unfortunately, later land use, especially the dramatic intensification of viticulture during the late nineteenth to early twentieth centuries, resulted in the creation of tens of thousands of clearance cairns over the whole island. Consequently, identification of earlier mounds within this landscape is very difficult and is generally confined to the larger examples. Many smaller mounds probably exist submerged within later clearance.

Only 18% of the mounds that are recorded in the island's Sites and Monuments Register have provided evidence of an internal burial through excavation or chance discovery. Where information is available, all of these burials are prehistoric in date and range from the Earlier Bronze Age through to the first century B.C. These mounds vary in size from ten to more than thirty metres in diameter and they occur singly and in groups. Whilst almost invariably constructed of stone, one example of a mound constructed of scooped up earth was recently discovered at Zemunjeva Gomila. Figs. 15.12 and 15.13 show the distribution of cairns and tumuli across the island. The dual use of these mounds as funerary monuments and agricultural clearance mounds within prehistory should be reflected in their distribution and this should be linked to the territories of major settlements.

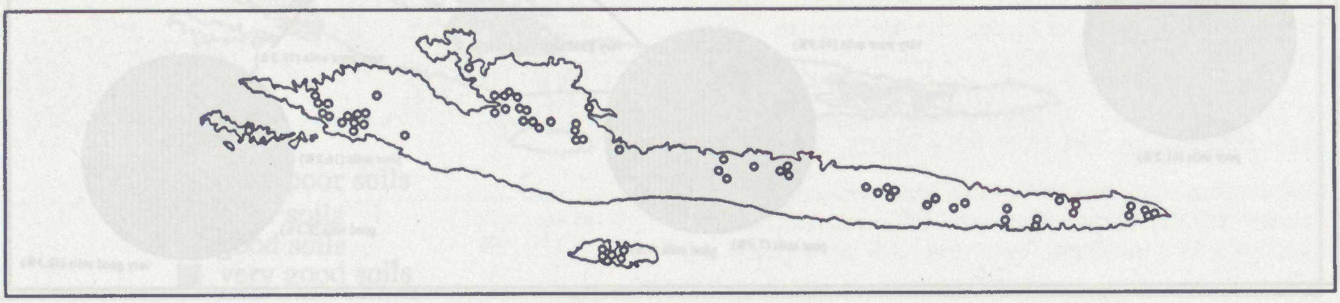
The most direct method to illustrate association between these monuments and agriculture is through the GRASS statistical module, the output of which is illustrated below in Table 15.2 provides a Chi Square analysis of the relationship between the numbers of sites and their occurrence on good soils.

	%age Cover	Expected Sites	Actual Number	Chi Square	Degs. of Freedom
Very Good	21.00	39.40	73	28.603	1
Good	18.9	35.60	11	16.96	1
Poor	30.8	57.90	6	20.283	1
Very Poor	29.3	55.10	4	23.103	
Total	100.00	188.00	188		

Table 15.2: Statistical Association between cairns, tumuli and soil type. Please note that cairns occurring on areas without soil classification data are excluded from this table.

There is a clear statistical association between cairns and tumuli and the very best agricultural soils. Cairns and tumuli occurring on poor and very poor soils show a negative correlation. If major hillforts are placed to dominate good agricultural land and cairns in part reflect the intensity of prehistoric agriculture there should be a coincidence between the distributions of both sites. In order to investigate this we have overlaid the distribution of cairn sites over agricultural land in the eastern part of the island in Fig. 15.14. This clearly shows the positive relationship between good soils and cairns and tumuli. However, it is significant that whilst there is a coincidence between the distribution of cairns and good soils within the catchments of Vela Glava and Liković, there is also a significant concentration of stone mounds in the area of good agricultural soils in between these sites — in one of the areas where we had predicted that another site remains to be found.

Figure 15.12: The distribution of stone cairns.



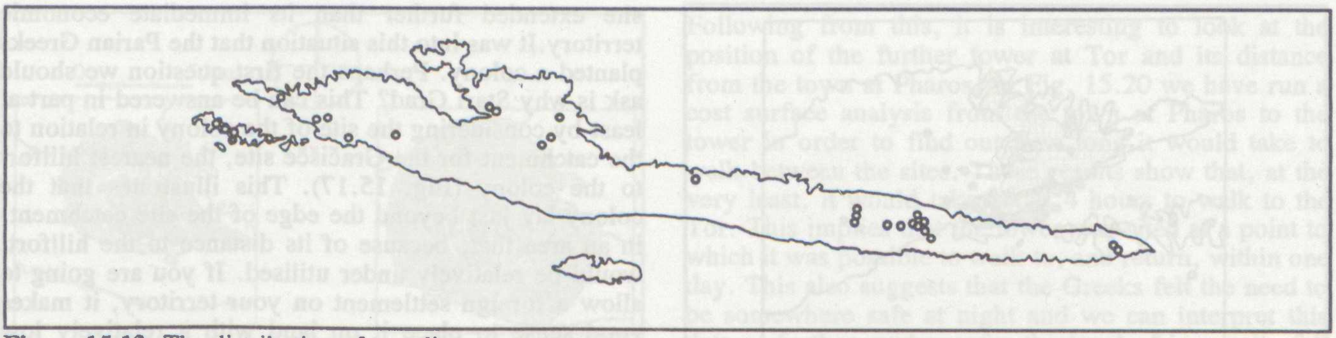


Figure 15.13: The distribution of tumuli.

The area to the north-east of Hvar is more problematic. There is no other archaeological evidence to suggest the presence of another site here. Fig. 15.15 shows the distribution of cairns on the Western part of the island and includes this area between the hillforts at Lompić and Hvar. Despite the availability of good soil there are very few recorded cairns in the area. This may reflect the lack of survey work within the area, however, we should not discount the possibility that the difficulties of obtaining adequate water supplies on the upland plain may well have discouraged settlement within this area. An alternative suggestion which will be outlined below is that this area may have rested under the control of the site at Hvar castle and that a separate major hillfort might not have been able to develop here.

The distribution of cairns within the catchment of the site at Hvar Castle in Fig. 15.15 contains several other notable features. Within this catchment, good soils are generally restricted to the flysch zone which lies to the east of Hvar Castle hillfort. Although there is a concentration of barrows around this zone, the flysch itself is soft and there is less need for the massive clearance seen on other geologies of the island. However, the most spectacular concentration of mounds around Hvar is to the north west of the town and is concentrated around the bay at Vira (Fig. 15.16, Zaninović 1978). The large size of the group and the position it occupies just beyond the edge of the Hvar catchment sets it apart. It does not have an obvious agricultural rationale. It lies within an area of poor soil, forming part of the Pelegrin peninsular which in the past was largely used for communal grazing. The layout of the cemetery is also rather peculiar. All the barrows are intervisible with a small barrow on the central peninsular and it is possible that this peninsular was isolated by a wall. The qualities of the cemetery at Vira strongly suggests an important ritual site associated with the settlement at Hvar Castle.

The above analysis suggests that a complex economic and political situation existed on Hvar prior to the arrival of the Greeks. There were six, possibly seven, individual social groups existing on the island prior to the arrival of the Greeks, each with its own central place. These sites were situated to dominate extensive areas of fertile land. The distribution of cairns and tumuli indicates that these areas were being utilised during the prehistoric period. Two of the sites, Liković and Hvar Castle may have been associated with major ritual sites. Hvar Castle with the Vira barrow cemetery and Liković with the enclosure at Grčka Gomila. There

Figure 15.14: The distribution of cairns and tumuli within hillfort catchments on the eastern part of the island of Hvar.

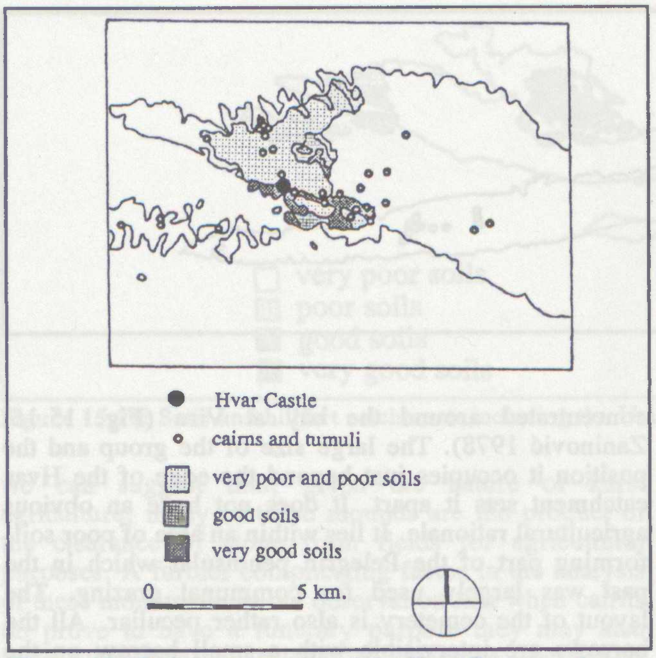


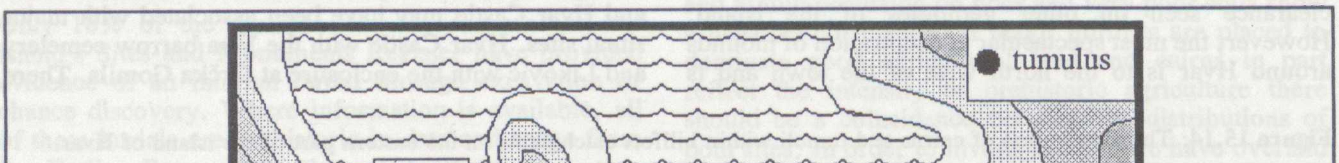
Figure 15.15: Cairns, tumuli and the Hvar Castle catchment.

are further indications that the status and perhaps the power of the site at Hvar exceeded that of other settlements on the island. To date only two sites on the island have produced early imported Apulian pottery — Hvar Castle and Lompić. The site at Lompić makes no sense as an independent settlement and we can suggest that it was connected to the site at Hvar Castle, perhaps as an outpost to watch the Stari Grad bay. Here, at least, we have the suggestion that the influence of one site extended further than its immediate economic territory. It was into this situation that the Parian Greeks planted a colony. Perhaps the first question we should ask is why Stari Grad? This can be answered in part at least by considering the site of the colony in relation to the catchment for the Gračišće site, the nearest hillfort to the colony (Fig. 15.17). This illustrates that the colony lay just beyond the edge of the site catchment, in an area that, because of its distance to the hillfort, would be relatively under utilised. If you are going to allow a foreign settlement on your territory, it makes good sense to place it on land with a relatively low economic value.

Whether the native Illyrians understood the implications of their actions is to be doubted. Having allowed the colony to be founded, they probably viewed the actions of the Greeks with some alarm, especially as they 'founded a city by the sea and built a wall around it'. A task viewed as a necessity by the colonists, planted as they were in a foreign land and on a plain with no natural defences, but perhaps construed as an aggressive act by the Illyrians.

Whatever the reasons, the result was a serious conflict which Diodorus has recorded. But was the battle between the Greeks and natives as definitive as Diodorus would like us to believe? The distribution of Greek sites on the island is almost entirely restricted to the Stari Grad plain (Fig. 15.18). It is very likely that the Greeks were confined to this area and the rest of the island remained in the hands of the native Illyrian peoples. It is also significant that there is a notable lack of Greek settlement sites within the Greek field system

Figure 15.16: Tumuli within the bay at Vira (after Zaninović 1978).



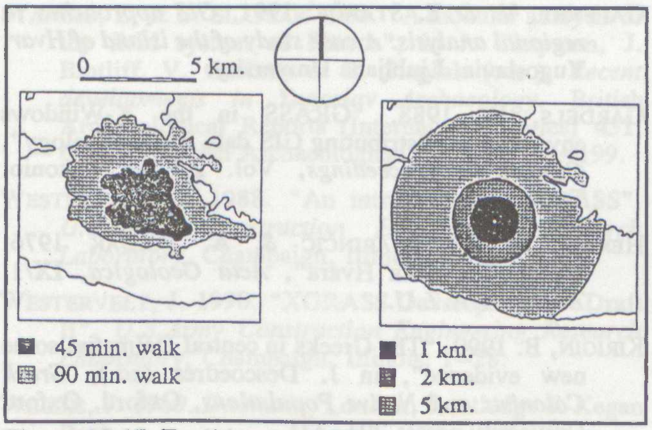


Figure 15.17: Traditional and GIS derived catchments for the Gračišće hillfort.

on the plain. This suggests that the majority of colonists remained safe within the town and they rarely felt secure enough to build permanent settlements outside of Pharos.

Another sign of the tension on the island is the presence of Greek watchtowers situated at Maslinovik and Tor. The better preserved tower at Tor is a fine example of Hellenistic work. It is constructed from massive blocks of stone with anathyrosis at the corners and stands on a high ridge overlooking the plain of Jelsa. The recently discovered tower at Maslinovik is badly damaged and only survives to slightly above foundation level. There is another defensive site at Purkin Kuk which has been claimed to be part of this system (Zaninović 1983). This is incorrect. The style of construction at this site is very different, amounting to little more than a copy of the towers at Maslinovik and Tor.

It is assumed that these towers form an integral system connected to the town at Pharos whereby watch was kept for any approaching danger. Whenever some enemy approached, the townsfolk would have been alerted to their peril by signals from the towers probably in the form of fire or smoke (Kirigin & Popović 1988). This assumption involves the existence of clear lines of sight between the sites or at least from the middle point at Maslinovik. We can use GIS to test this belief. Intervisibility between points can be demonstrated by interrogating the Hvar DEM to allow us to plot the areas which are in direct visual contact with a specified point. The results using the tower at Maslinovik as the starting point are shown in Fig. 15.19. We can see from this illustration that Maslinovik would have been able to see the tower situated to the South East at Tor and be in a position to pass any warning to the inhabitants of Pharos to the west.

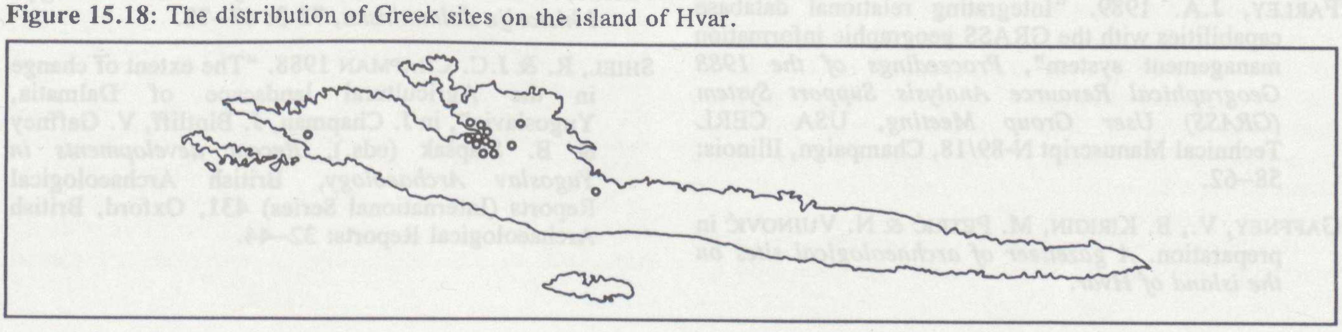
Following from this, it is interesting to look at the position of the further tower at Tor and its distance from the town at Pharos. In Fig. 15.20 we have run a cost surface analysis from the town at Pharos to the tower in order to find out how long it would take to walk between the sites. These results show that, at the very least, it would take about 4 hours to walk to the Tor. This implies that the tower was sited at a point to which it was possible to walk to, and return, within one day. This also suggests that the Greeks felt the need to be somewhere safe at night and we can interpret this data as further evidence for the level of insecurity felt by the Greek colonists.

15.7 Conclusions

Diodorus did not lie. In 385/4 B.C. the Greeks founded a colony at Pharos on Hvar. They probably fought a battle with the native population on the island. The impression given by Diodorus, however, that the Greek victory was so overwhelming must be open to doubt. The battle undoubtedly gained the Greeks access to the Stari Grad plain, the largest fertile area on the island, and this must have been at the expense of the inhabitants of Gračišće. One assumes that this is the 'exceedingly well fortified site' mentioned in Diodorus' text. The plain largely falls within the field system upon the plain indicates the ceding of the a and a considerable portion of the Gračišće catchment at least to the colony. But beyond this, how successful were they? There is no indication that Greek settlement extended beyond the plain as one might expect after an overwhelming victory. Indeed there is little evidence that permanent Greek settlement or power existed to any significant extent beyond the walls of the colony. This and the positioning of the defensive towers at Maslinovik and Tor suggests that, having arrived at Pharos, the Greeks were largely restricted to the Stari Grad plain. Elsewhere on the island, the native communities continued.

Having started off the paper with a quote from Sir Moses Finley on the needs of ancient historians and the procedures of archaeologists, we can only end with the sincere hope that we have fulfilled some of his demands. The application of GIS to the archaeological, historical and environmental data for the island of Hvar has proved an invaluable tool and the provisional results presented here have extended our understanding of the data considerably. We consider that the potential of the techniques within archaeology are far greater than is indicated by this paper alone. We might also add that having used GIS techniques on the Hvar data we find the prospect of a return to Finley's 'pencil and paper and elementary numeracy' rather difficult to

Figure 15.18: The distribution of Greek sites on the island of Hvar.



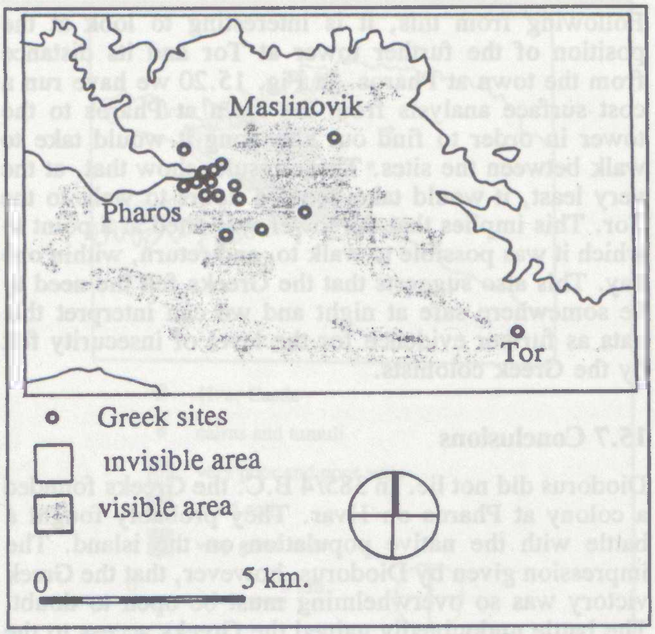


Figure 15.19: Visibility analysis based on the Greek tower at Maslinovik.

contemplate, though we heartily endorse his view that a simple computer could do no harm.

References

BATOVIĆ, S. 1984. "Contribution aux étude de la céramique corinthienne sur la côte orientale de l'adriatique", *Vjesnik za arheologiju i historiju dalmatinsku*, 77: 37–62.

BINTLIFF, J.L. 1977. *Natural Environment and Human Settlement in Prehistoric Greece*, British Archaeological Reports (Supplementary Series) 28, Oxford, British Archaeological Reports.

BOWDEN, M.C.B. & D. MCOMISH 1987. "The required barrier", *Scottish Archaeological Review*, 4, Part 2: 76–84.

BOWDEN, M.C.B. & D. MCOMISH 1989. "Little boxes: more about hillforts", *Scottish Archaeological Review*, 6: 12–16.

CHAPMAN, J.C. 1981. "The value of Dalmatian museum collections to Dalmatian settlement studies", in A.M. Cantwell, J.B. Griffin & N.A. Rothschild (eds.), *The research potential of Anthropological museum collections*, Annals of New York Academy of sciences, 376: 529–555.

CHAPMAN, J.C., R.S. SHIEL & S. BATOVIĆ 1987. "Settlement patterns and land use in neothermal Dalmatia 1983–4", *Journal of Field Archaeology*, 14: 124–146.

FARLEY, J.A. 1989. "Integrating relational database capabilities with the GRASS geographic information management system", *Proceedings of the 1988 Geographical Resource Analysis Support System (GRASS) User Group Meeting*, USA CERL Technical Manuscript N-89/18, Champaign, Illinois: 58–62.

GAFFNEY, V., B. KIRIGIN, M. PETRIĆ & N. VUJNOVIĆ in preparation. *A gazetteer of archaeological sites on the island of Hvar.*

GAFFNEY, V. & Z. STANČIĆ 1991. *GIS approaches to regional analysis: A case study of the island of Hvar*, Yugoslavia, Ljubljana University.

GARDELS, K. 1988. "GRASS in the X-Windows environment distributing GIS data and technology", *GIS/LIS'88 proceedings*, Vol. 2, San Antonio, Texas: 751–758.

HERAK, M., S. MARINČIĆ & A. POLŠAK 1976. "Geologija otoka Hvara", *Acta Geologica*, IX/1, Zagreb, J.A.Z.U.

KIRIGIN, B. 1990. "The Greeks in central Dalmatia: some new evidence", in J. Descoedres (ed.), *Greek Colonists and Native Populations*, Oxford, Oxford University press: 291–321.

KIRIGIN, B. & P. POPOVIĆ 1988. "Maslinovik — a Greek watch tower in the chora of Pharos. A preliminary report", in J. Chapman, J. Bintliff, V. Gaffney & B. Slapšak (eds.), *Recent developments in Yugoslav Archaeology*, British Archaeological Reports (International Series) 431, Oxford, British Archaeological Reports: 177–189.

KOVAČIĆ, V. 1989. "Stari Grad na otoku Hvaru", *Arheološki Pregled 1987*: 85–86.

LOZAR, R.C. & W.D. GORAN 1987. "GRASS for military land use planning", *The Military Engineer*, August 1987: 468–469.

MADRY, S.L.H. 1989. "Geographic Resources Analysis Support System (GRASS), an integrated public domain GIS and image processing system", *GIS/LIS'89 proceedings*, Vol. 2, Orlando, Florida: 743–750.

MAROVIĆ, I. 1985. "Iskopovanje kamenih gomila u Bogomolju na otoku Hvaru", *Vjesnik za arheologiju i historiju dalmatinsku*, 78: 5–33.

NOVAK, G. 1955. *Prethistorijski Hvar*, Zagreb.

NOVAK, G. 1959. "Istraživanje spilja Ormanice i Markove i gradine Gračišće na otoku Hvaru", *Ljetopis J.A.Z.U.*, 63, Zagreb: 319–325.

PARKER, S.C. 1989. "The design and implementation of an exploratory data analysis system (S-GEO) for integrating with GRASS, remote sensing and database management", *Proceedings of the 1988 Geographical Resource Analysis Support System (GRASS) User Group Meeting*, USACERL Technical Manuscript N-89/18, Champaign, Illinois: 47–50.

PETRIĆ, M. 1986. "Izvještaj o arheološko-konzervatorskim radovima na ruševini Gazarovic u Hvaru", *Periodični izvještaj centra za zaštitu kulturne baštine komune Hvarske*, 156: 7–17.

PETRIĆ, N. 1979. "Hvarski tumuli" *Vjesnik za arheologiju i historiju dalmatinsku*, 72-3: 67–78.

SHIEL, R. & J.C. CHAPMAN 1988. "The extent of change in the Agricultural landscape of Dalmatia, Yugoslavia", in J. Chapman, J. Bintliff, V. Gaffney & B. Slapšak (eds.), *Recent developments in Yugoslav Archaeology*, British Archaeological Reports (International Series) 431, Oxford, British Archaeological Reports: 32–44.

STANČIĆ, Z. & B. SLAPŠAK 1988. "A modular analysis of the field system of Pharos", in J. Chapman, J. Bintliff, V. Gaffney & B. Slapšak (eds.), *Recent developments in Yugoslav Archaeology*, British Archaeological Reports (International Series) 431, Oxford, British Archaeological Reports: 191–199.

WESTERVELT, J. 1988. "An introduction to GRASS", *U.S.Army Construction Engineering Research Laboratory*, Champaign, Illinois: 1–11.

WESTERVELT, J. 1990. "XGRASS Development — Draft II", *U.S.Army Construction Engineering Research Laboratory*, Champaign, Illinois: 1–28.

WILKES, J. 1969. *Dalmatia*, London, Routledge & Kegan Paul.

YORSTON, R. 1987. "Theory and method: some observations from a scientist", in C. Gaffney & V. Gaffney (eds.), *Pragmatic Archaeology: Theory in Crisis?* British Archaeological Reports (British Series) 167, Oxford, British Archaeological Reports: 17–26.

ZANINOVIĆ, M. 1978. "Novi prilozi arheološkoj topografiji otoka Hvaru", *Novija i neobavljana istrazivanja u Dalmaciji*, Izdjanje HAD-a 3, Split: 49–62.

ZANINOVIĆ, M. 1982. "Nalazi sa Tora kod Jelsa kao prilog njegovoj kronologiji", *Opuscula Archaeologica*, 7, Zagrab: 61–76.

ZANINOVIĆ, M. 1983. "Illyro Hellenistic sites on the island of Hvar (Pharos)", *Actes VII congres de F.I.E.C.*, 1, Budapest: 381–384.

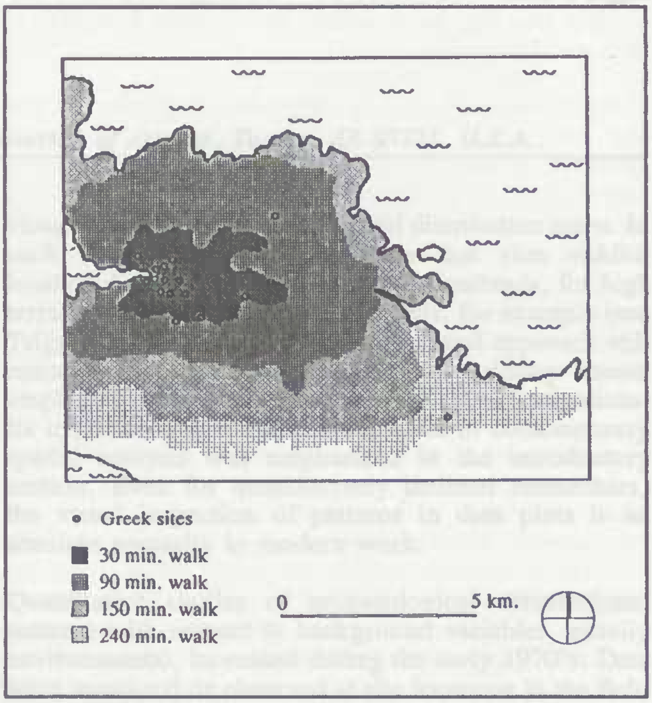


Figure 15.20: Cost surface analysis between Pharos and the tower at Tor.