ARCHAEOLOGY AND DESERTIFICATION IN THE VERA BASIN (ALMERÍA, SOUTH-EAST SPAIN)

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Abstract: Field research and predictive modelling of global warming and desertification by environmental scientists in the Mediterranean has concentrated on the short term. In this paper, it is argued that collaboration between the historical sciences, especially archaeology, and the environmental sciences can provide a longer-term perspective on desertification in the Mediterranean. Such collaboration has taken place recently in the Vera basin (Almería, south-east Spain), with the financial support of the European Union. Details of the archaeological and historical sequences of occupation in the basin are given, before presenting the main trends in demography, settlement and political systems from 4000 BC until the present day. This is followed by details of the long-term record of degradation in the Vera basin. The paper concludes by using the long-term record to propose recommendations for the future management of this landscape.

Keywords: archaeology, demography, desertification, long-term perspective, political systems, settlement, south-east Spain

INTRODUCTION

In their recent, edited book on Mediterranean Desertification and Land Use, Jane Brandt and John Thomes (1996:xvii) list changes which have taken place in ‘traditional’ Mediterranean societies and landscapes since the middle of the twentieth century. These changes include the migration of people from rural areas to the cities, the expansion of the tourist industry in coastal areas, the modernization and intensification of land use (focusing on tree crops and vegetables under various forms of irrigation), the abandonment of land used for extensive agriculture and pastoralism, and increased demand for water (for both tourism and irrigation). These changes respond to the economic needs of late twentieth-century nation...
states and their demands for labour. They also have visible consequences for Mediterranean landscapes, which have been the object of exploitation by agricultural societies during the last 9000 years. Vegetation has been stripped, soil eroded, water polluted and aquifers drained. This is part of a process of desertification, defined by the United Nations Environmental Programme as 'land degradation in arid, semi-arid and dry subhumid areas resulting from various factors, including climatic variations and human activities' (Thornes 1996:1). As if the 'human activities' were not bad enough, the degree and possible effects of global warming make research into Mediterranean desertification both a more complex and a more urgent task.

The response to the threat of global warming and desertification in the Mediterranean is being funded by national governments and by the European Union. The focus for research is on the collection of data that will enable predictive modelling, thereby providing a basis for government policy and action in the twenty-first century. The principal areas of concern are the future of land use and the tourist industry (e.g. Jeftic et al. 1992). EU research projects such as MEDALUS (Mediterranean Desertification and Land Use) have begun with the analysis of degradation processes on a small scale and the collection of standardized measurements on climate, vegetation, land use and soils at field stations throughout the Mediterranean basin (Brandt and Thornes 1996). Models of, for example, the impacts of climate and land use on hydrology and soil erosion (Bathurst et al. 1996), or the response of landscape units to desertification (Imeson et al. 1996), have been proposed on the basis of these data. The directors of the project acknowledge the need for larger-scale studies, at the level of the catchment and the region, as well as the importance of research into the socio-economic context of desertification.

But what about the time-scale of such research? What can we learn about the process of desertification by focussing on the long-term rather than the short-term? In south-east Spain, studies of precipitation, flooding and soil erosion in recent decades (e.g. Thornes 1976 on the floods of 1973; Harvey 1984 on the 1980 storm over Tabernes; López Bermúdez and Romero-Díaz 1989 on the Mula basin, Murcia; Calvo-Cases et al. 1991 on badland development) have been extended back over the last millennium by the use of historical evidence: for example Molina Sempere et al. (1994) have compiled a record of floods in the Segura basin since the ninth century AD, showing their increased frequency during the last four centuries and their association with major periods of deforestation and land abandonment. But the much longer prehistoric record of land use, settlement, demography and environmental impact in south-east Spain (and elsewhere) is scarcely mentioned: Grove (1996) devotes a page to the prehistoric cultures of the Mediterranean in his review of environmental change before AD 1850. Brandt and Thornes (1996:xvii) note for the Mediterranean as a whole that 'by Classical times, the land had already been extensively deforested and eroded', while Puigdefabregas and Mendizabal (1998:211) appear to dismiss Mediterranean landscape changes prior to the last 500 years as irrelevant to desertification research (in their words, 'human influence was lacking or very limited').
In this article, we argue that collaboration between the historical sciences (including archaeology) and the environmental sciences can provide a relevant, long-term perspective on desertification in the Mediterranean. While the short-term observations of projects such as MEDALUS provide us with unique details on contemporary erosion processes, it is the long-term record which enables us to see whether these processes are exceptional, in either their scale or frequency, and to what extent their causes and consequences may be determined by the historical sequence of human activities in the same region. We begin by introducing readers to the study region – the Vera basin, in the eastern part of Almería province, south-east Spain. This is located in the driest area of Europe. It also has a record of archaeological activity from the 1880s and a sequence of prehistoric and historic settlement that must be among the most detailed in the Mediterranean. After a summary of research activity and the sequence of occupation, we focus attention on the main trends in demography, settlement and political systems, as inferred from archaeological and historical data, and their relationship to land use and environmental change. We conclude with a discussion of future policy for land use and water management within the Vera basin.

THE VERA BASIN: CONTEXT AND RESEARCH HISTORY

The coastal lowlands of Almería in south-east Spain are known as the most arid region of Europe, below the 400 mm isohyet and marked by irregular, localized and unpredictable rainfall on an annual and inter-annual basis (Neumann 1960; Freitag 1971). This region has been marked in modern times by a decrease in precipitation (Puigdefabregas and Mendizabal 1998:211), lower water tables (e.g. Ochoa et al. 1973), stress on aquifers (e.g. Chabarte et al. 1996; Herget 1998:54-55), increased flooding (Molina Sempere et al. 1994), and eroded and badland landscapes (e.g. Calvo-Cases et al. 1991).

The Vera basin is located in eastern Almería and comprises an area of some 25 km from north to south and 15 km from east to west (Fig. 1). The northern, western and southern sides of the basin are delimited by sierras of the Baetic system (Almagrera, Almagro, Bédar, Cabrera), while the east faces the Mediterranean. The basin is drained by three rivers – the Almanzora in the north, the Antas in the centre and the Aguas in the south. Populations have traditionally been concentrated in towns such as Cuevas de Almanzora, Vera and Antas in the Miocene lands of the basin, but the growth of the tourist industry has coincided with the expansion of population centres on the coast around Mojácar and Garrucha. Large areas of dry cultivation have been abandoned in the basin since the earlier part of the twentieth century. A current trend concerns the expansion of the irrigated cultivation of tomatoes under plastic greenhouses, although this is still not as extensive as occurs in the south of Almería (e.g. in the campo de Nijar, or the campo de Dalias).

Archaeological research in south-east Spain began in the 1880s, with the arrival of two Belgian mining engineers, Louis and Henri Siret, who lived initially in Cuevas de Almanzora in the north of the Vera basin. Such was their enthusiasm...
for archaeology that by 1887 they were able to publish an account of the prehistoric settlements and burials they had discovered in the basin, and immediately to the north in southern Murcia, organized in a sequence from the Neolithic to the Bronze Age (Siret and Siret 1887).

Although the Sirets' account can now be challenged in terms of chronology and interpretation, it has determined the context and direction of research until very recent times. Indeed, there were few new excavations on the 'classic' sites in the Vera basin, or elsewhere in the lowlands of south-east Spain, from the 1880s until the last two decades. In the Vera basin, there have been recent excavations on Neolithic and Copper Age sites at Cuartillas (Fernández-Miranda et al. 1987), Las Pilas (Alcaraz Hernández 1992), Campos (Martín Socas and Camalich 1986; Camalich et al. 1987a), Zájara (Camalich et al. 1990a, 1992), Santa Bárbara (Martín Socas et al. 1992-1993), Cerro Virtud (Montero and Ruiz 1996) and Almizaraque, which has the key stratigraphy (Delibes et al. 1986). For the Bronze Age, there have been two major re-excavations of the Sirets' sites – at Fuente Alamo, in the north of the basin, since 1978 (Schubart and Arteaga 1978, 1980; Schubart et al. 1986, 1989, 1993; Schubart and Pingel 1995), and at Gatas,
on the southern edge in the Aguas valley, since 1986 (Chapman et al. 1987; Castro et al. 1999, and publications cited therein). The data from these two sites provide the basis for a detailed account of Bronze Age chronology, material culture, mortuary practices, subsistence and environment in the Vera basin.

In addition to excavations, a number of survey projects has taken place recently in the Vera basin (e.g. Camalich et al. 1987b, 1990b; González Quintero et al. 1992; Fernández-Miranda et al. 1993; Delibes et al. 1996). This extension of research from individual sites to the basin as a whole was further marked by the initiation of two successive, EU-funded projects, which combined survey with site sampling to present a diachronic account of population, settlement and environmental change from c. 4500 cal BC until the present day (the C-14 chronology which is used in this paper is based on calibration of conventional and AMS dates using version 3.0 of the CALIB programme of the University of Washington – see Castro et al. in press). The Archaeomedes project (‘Understanding natural and anthropogenic causes of desertification and land degradation in the Mediterranean basin’) included the Vera basin as one of its four study areas from 1992 to 1994. The Aguas project (‘Palaeoclimatic reconstruction and the dynamics of human settlement and land-use in the area of the middle Aguas (Almería) in the south-east of the Iberian Peninsula’) was undertaken from 1994 to 1996 (Castro et al. 1998).

Eleven periods of occupation of the Vera basin have been defined prior to the Christian reconquest in the sixteenth century (Table 1). For the prehistoric periods, it should be noted that the Vera basin was at the centre of changes to social inequality which have brought south-east Spain to the attention of European archaeologists (for a summary of the main models, see Chapman 1990:141–147). Since that period, the basin has occupied a more peripheral political position, along with much of the rest of south-east Spain, and has been the subject of external exploitation. The archaeological record of this exploitation, which forms the focus of this article, will be followed by a brief account of the historical record from the sixteenth to the twentieth centuries AD.

Table 1 Main prehistoric and historic occupation periods in the Vera basin. Dates for periods 1–4 are based on calibrated radiocarbon determinations, while those for periods 5–11 are based on historical sources.

<table>
<thead>
<tr>
<th>Period</th>
<th>Dates</th>
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<tbody>
<tr>
<td>1. Neolithic</td>
<td>4500–3000 BC</td>
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<tr>
<td>2. Chalcolithic</td>
<td>3000–2250 BC</td>
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<tr>
<td>3. Argaric</td>
<td>2250–1550 BC</td>
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<td>4. Post-Argaric</td>
<td>1550–900 BC</td>
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<td>5. Phoenician I</td>
<td>900–200 BC</td>
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<td>6. Phoenician II/Republican Rome</td>
<td>200–27 BC</td>
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<tr>
<td>7. Imperial Roman</td>
<td>27 BC–AD 400</td>
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<tr>
<td>8. Late Roman</td>
<td>AD 400–550</td>
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<tr>
<td>9. Visigothic – Byzantine</td>
<td>AD 550–718/750</td>
</tr>
<tr>
<td>10. Omeya</td>
<td>AD 718/750–11th century</td>
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<tr>
<td>11. Nazarene</td>
<td>AD 1232/1237–1492</td>
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Demography, settlement and political systems from 4500 cal BC

Archaeologists who wish to reconstruct changes in prehistoric population size and density have most frequently resorted to the use of cross-cultural formulae relating population size to the area occupied by individual settlements (Hassan 1981). Given the attention given to demographic variables in models of social change, and the investment of resources in surface survey since the 1950s, the use of such formulae has provided the basis of local and comparative studies of population size and density in the Old and New Worlds (e.g. Wright 1986). Critics of such formulae argue that (1) the relationship between population size and site area is not necessarily linear and may only be ‘extremely broad’ (Whitelaw 1991:149), (2) the processes which determine the relationship between people and space require prior analysis (e.g. Fletcher 1981) and may complicate the search for simple size-area formulae (e.g. differences in the use of space and densities of population in different levels of settlement and social hierarchies [see Hodder 1982:123; Schreiber and Kintigh 1996]), (3) the definition of site areas from surface survey data depends upon the survey and analytical methodologies employed and the formation processes which have determined the scatters of surface materials collected by archaeologists (Cherry et al. 1991), and (4) data on houses and floor areas from excavated settlements provide a more reliable measure of population size (Schreiber and Kintigh 1996).

We do not deny the difficulties involved in palaeo-demographic analyses. While archaeologists in some areas of the world may make use of ethnographic analogy through the direct historical method (Curet 1998), this avenue of inquiry is not open to us in much of the Old World. For south-east Spain archaeologists have yet to collect data of the necessary extent and precision to allow population calculations from houses and floor areas. Contemporaneity of sites with comparable material cultures is assumed within periods of hundreds of years (e.g. ‘Neolithic’, ‘Chalcolithic’). Surface surveys have employed different, and often unspecified, methodologies, and have yet to be published in the kind of detail now standard for the east Mediterranean (e.g. Cherry et al. 1991). Clearly dateable material, such as pottery types, has not always been recovered from surface collections (Delibes et al. 1996), while the preservation of sites within the Vera basin has been affected by modern landscape change. In spite of these difficulties, we believe that it is important to begin palaeo-demographic study, even if only to set up hypotheses for future evaluation (Chapman 1990). In what follows, we propose a sequence for the demographic development of the Vera basin during the last 6000 years. It is the order of magnitude of changes through time that is of interest to us, rather than claims for precise figures.

Given the excavation and survey data which was drawn together in the Archaeomedes and Aguas projects, we have made population estimates for each period of occupation. From the last 500 years, these estimates are based on historical documents but, for earlier periods, we have used the surface areas of sites to calculate what we have termed ‘maximum’ and ‘minimum’ population figures for the basin. Some modifications to the maximum (based on Renfrew 1972) and minimum
(based on Kramer 1978) estimates were made to allow for periods such as the Neolithic or Chalcolithic, when we suggest there was still some degree of settlement mobility. Population curves are calculated for the Vera basin as a whole as well as the middle and lower Aguas valleys (Fig. 2). An alternative formula for calculating population numbers in the Argaric and Post-Argaric Bronze Age (c. 2250–1200 cal BC), based on flour production from the grinding stones found in the excavations at Gatas, provided a higher estimate than did the site area data. Further details of these palaeo-demographic calculations are given in Castro et al. (1998:22–23). For the period AD 1500–1600, demographic estimates have been made on the basis of both the archaeological and historical records. The scale of demographic change is also discussed as a result of comparison of population estimates for the Vera basin and for its southernmost area in the Aguas valley.

For the Vera basin as a whole, there are four peaks in population size. The first of these occurs in the Argaric Bronze Age, after a major settlement and cultural dislocation. Neolithic sites are small and ephemeral, and their long distribution throughout the late fifth and fourth millennia BC mean that their cultural and chronological attributes are poorly defined. Small populations of agriculturalists still seem to have incorporated a degree of mobility in settlement patterns, which included sites with prime access to cultivable land (both for dry-farming and horticulture) and others located to exploit the resources of the sierras surrounding the basin. Population increased during the third millennium BC, during the local Copper Age (named after the fortified settlement of Los Millares, in the Andarax valley in southern Almería), when settlement location suggests increased agricultural colonization of the basin and increased sedentism (as also attested by stone structures and stratified occupation deposits at Almizaraque and Las Pilas). Evidence of division of labour in metal and lithic production (e.g. at Campos, Santa Bárbara and Almizaraque), as well as differences in access to exotic materials in communal megalithic tombs, and the existence of fortifications around settlements, all suggest inequality in access to wealth, to the labour force and to political power. It has been possible to show that the key element in this emerging inequality was the capacity to control and increase the labour force in certain groups and settlements (Micó 1992; Risch 1995). It is this inequality which increases markedly at the end of the third millennium BC, when the Copper Age settlements in the bottom of the basin were abandoned. With the notable exception of El Argar and a number of smaller sites, population became nucleated on steep, artificially terraced and easily defended slopes in the foothills of the sierras which surround the basin. In the Aguas valley, for example, the numbers of known sites decrease by more than 50 per cent. Extramural communal burial is replaced by intramural individual interment in cists, urns or pits. Metal production in copper, gold and silver increases by a factor of 5 and pottery production was marked by standardization. The distribution of wealth items in burials, along with evidence for economic exploitation (Lull and Risch 1996), support the inference of class relations and a state society.

Excavations at Fuente Alamo and Gatas indicate that the economic basis of Argaric populations in the Vera basin was initially one of extensive dry-farming of cereals coupled with more localized horticulture of leguminous species and flax
Figure 2. Demographic change in the Vera basin (top) and the Aguas valley (bottom) from c. 4000 BC to the present day. The maximum (Dem+) and minimum (Dem-) estimates based on surface areas are shown along with the estimates based on Bronze Age flour production (Dem.Arch.) and on historical documents (Dem.Hist.).
The Tertiary plains surrounding settlements were gradually denuded of open *maquia* and evergreen woodland and of the deciduous trees which were present alongside active rivers and streams. This process accelerated during the last two centuries of the Argaric, c. 1700-1500 cal BC, through the practice of barley monoculture and increased agricultural production and labour investment. Not only was vegetation clearance extended to areas more distant from Argaric settlements but the presence of waste and saline areas is suggested in pollen diagrams (Castro et al. 1998:68) and by the seeds of wild plants. The relationship between site size and accessible cultivable land suggests that smaller settlements in the bottom of the basin were responsible for primary agricultural production, while the larger settlements in the surrounding foothills received tribute from them through the exercise of politico-economic control. This emergence of a stratified, regional, political economy, with its deleterious consequences for the land and landscape of the Vera basin (Castro et al. 1999), took place when maximum annual temperatures were similar to, or even slightly higher than, today's values and winter temperatures may have been slightly milder (Castro et al. 1998:43).

The nature of the social and political changes which took place at the end of the Argaric, c. 1550 cal BC, are still in need of clarification. The sequence at Gatas supports the definition of two Post-Argaric periods: Bronce Tardío (1500-1300/1250 cal BC), in which intramural burial disappears, along with some distinctive metal and pottery types, and Bronce Final (c. 1300/1250–900 cal BC), which precedes the Phoenician colonization of southern Spain. Although there was an initial increase in the dietary range of local communities, there was a marked decrease in agricultural production, as indicated by the frequency and condition of grinding stones (Castro et al. 1999). Consequently, the vegetation cover was denuded further: clearance of the *maquia* continued at middle and lower altitudes, the deciduous species finally disappeared from along low-lying watercourses, and there are indications of saline soils in an increasingly steppe-like landscape. Our calculations suggest a population decline to a size comparable to that proposed for the Copper Age, living mostly in new settlements, mostly of small size and focussed on agricultural production in the lowlands. The environmental impact of the Argaric political system was clearly felt in the second half of the second millennium BC. What is not clear is how this impact tied in with the documented decrease in mean annual temperatures by 1°C from 1500 to 1300 cal BC, and by a further 1.5°C from 1300 to 1000 cal BC (Castro et al. 1998:43).

The second major peak in the Vera basin coincides with the Phoenician colonization of the early first millennium BC, when population rose again to the level of the Argaric period. This rise must be largely due to the foundation and associated influx of population of the 9-hectare town at Villaricos, on the north side of what was then an estuary of the Almanzora river, in the north of the basin. The concentration of settlement and population in the lower Almanzora focussed on trading ports and the major exploitation of the silver and lead ores of the sierra Almagrera and Las Herrerias. In contrast, there was a major settlement dislocation in the south of the Vera basin, with the abandonment of sites to the south of the Aguas river...
and only one known site immediately to the north of the river, at Cortijo de Riquelme. The population of the Aguas valley appears to have decreased by about 50 per cent, as the economic ‘pull’ of Villaricos determined regional settlement. In contrast to earlier periods, ‘with the Phoenician and Carthaginian colonisations, the Vera Basin became a subsidiary territory in the geo-political and economic interests of successive hegemonic states’ (Castro et al. 1994).

From the end of the second century BC, after the Second Punic War, south-east Spain became the ‘subsidiary territory’ of the Romans. During the initial Republican period, political conflict led to a marked population decrease but, during the Imperial and late Roman periods after AD 300, this trend was reversed to such an extent that between 7000 and 15,000 people may have lived there by the end of Roman rule. Not only did the number of settlements increase, but so also did the surface area occupied by these sites. In addition to local population growth, we also propose the hypothesis that immigration took place from New Carthage (modern Cartagena), where intensive agriculture and mining posed increasing problems of degradation. The city of Villaricos (Roman Baria) continued to be occupied until the late Roman period, increasing in size to 15 hectares. Iron, lead and silver continued to be exploited immediately inland from the city. In the low-lying Miocene lands of the basin, extensive agriculture was practised by large farms to maintain the increased population. In the north of the Aguas valley, the transition from Republican to Imperial periods was marked by the growth (or imposition?) of a more evenly dispersed settlement pattern. Areas which had been abandoned since the Copper Age (over 2000 years earlier) or the Post-Argaric (over 1000 years earlier) once again became focal areas for settlement and agricultural exploitation. The drive to recolonize the sierras surrounding the basin in the Republican period (e.g. at Fuente Alamo) came from the need for territorial control. For those areas recolonized in the late Roman period, it was soil exhaustion which played a more important role.

The political turmoil marking the Byzantine and Visigothic dominion over south-east Spain in the sixth, seventh and early eighth centuries AD led, not surprisingly, to a reduction of the Vera basin population by about 35-40 per cent. At the same time, systems of production and trade networks showed continuity from the Roman period. More fundamental changes occurred in the eighth century AD, with the Moorish conquest resulting in the introduction of new crops such as rice, oranges and mulberries and irrigation technology. The latter included canals and water-mills in the lowlands and terracing of the mountain-sides of the sierras Cabrera (in the south) and Bédar (in the west). While agricultural production expanded in such areas, other parts of the basin were unoccupied, such as the formerly important mining areas of the sierras Almagrera and Almagro, to the north of the Almanzora river. While the basin as a whole saw a continuous decline in population numbers, halving again from the estimates for the Visigothic period, there was an extra peak of population at the beginning of the fifteenth century in the Aguas valley. The conflict between Christian and Nazarene forces at this time was such that politico-defensive factors dictated regional settlement patterns and
population distributions; hence, Nazarene communities concentrated in the south of the basin.

The Christian conquest of the Nazarene kingdom of Granada, which included the Vera basin, took place in AD 1492. Historical sources record the population of the basin in AD 1495 as nearly 5500 but, by AD 1597, with the expulsion of the Moors, this figure had decreased to around 3600. Minimal population increase occurred in the seventeenth century (certainly no more than could be explained by local, natural growth), but, in the period from AD 1718 to 1752, the population of the basin more than doubled in size, to just over 14,000 inhabitants, probably due to immigration from Castile. At the same time, there was a marked increase in the area devoted to agricultural production: for example, the cultivated area of the municipalities of Cuevas, Turre and Vera increased from about 5200 hectares in the sixteenth century to approximately 13,000 hectares in the mid-eighteenth century AD. This increase was accompanied by growing inequalities in access to land, with irrigated land concentrated within the hands of wealthy landowners and immigrants being restricted to poorer, dry-farmed land.

Population continued to rise steeply into the nineteenth century throughout the Vera basin. By AD 1787 it had risen to nearly 20,000, by AD 1850 it had jumped to 29,000, and in AD 1877 it had just about peaked at 32,000. Immigration again played the dominant role in this process, this time caused by the growth of the lead, silver, copper and iron mining industry in the sierras Almagrera, Almagro and Bédar region in the north of the basin from AD 1839. By the 1840s, Spain was the main exporter of metals in Europe. The success of mining in the sierra Almagrera stimulated prospection for metals and other minerals elsewhere in the Vera basin (e.g. lead in the sierra de Bédar and silver in the sierra Cabrera), and throughout the lowlands of south-east Spain (Molina Sánchez 1991:130–131). The same sources that were mined intensively by the Phoenicians and the Romans in the sierra Almagrera were now re-exploited. The population of the municipality of Cuevas de Almanzora grew in size from 7000 to 20,000 inhabitants within half a century: by AD 1888, 60 per cent of its people lived in mining settlements immediately outside the town. But the need to sustain this large population increase had no effect on the landholding system of the basin, which remained under the control of a minority of landlords, while the majority of the rural population rented mainly poor-quality dry-farming land. The infrastructure required to support the basin’s population extended into the sierra Cabrera, where terracing reached almost as far as the summit.

By AD 1890, the mining industry in the Vera basin was in crisis. While ore deposits were being exhausted in the higher parts of the sierra Almagrera and flooding caused the major problem in the exploitation of the silver sources at Las Herrerías, it was the fall in lead and silver prices on the international markets and the rise of the United States as the world’s major lead producer which led to the local industry’s decline (Molina Sánchez 1991:283–289). The number of mines halved to 54 from AD 1886 to 1895, and halved again to 26 by AD 1915. The last seven mines were abandoned in AD 1936. This decline had an immediate impact on population levels throughout the Vera basin, which fell almost as rapidly as
they had risen in the previous century. Cuevas de Almanzora lost 50 per cent of its population through emigration in 25 years and, by AD 1970, there were just under 22,000 people in the Vera basin as a whole. At the present day, the figure is more like 15,000 people. The basin has now entered a phase of emigration to the big commercial and industrial cities outside of the south-east, combined with land abandonment as the tourist industry expands and attracts more local labour and expansion of the irrigated growth of vegetables, especially tomatoes, as the most profitable source of income from the land.

**Degradation in the Vera basin: the long term**

This 6000-year record of human activity in the Vera basin is the result of over a century of research by archaeologists in varying degrees of collaboration with historians and environmental scientists, although true interdisciplinary projects have only characterized the last two decades. The quality of the data is variable, both in time and space, but a number of trends may be observed.

During the course of human occupation, settlement patterns and population distributions have been marked by both continuity and dislocation, by aggregation and dispersal, and by periods of localized abandonment for anything up to two millennia. Even within a comparatively small area like the Vera basin, there were scalar differences in the social exploitation of nature according to the focal areas of political and economic activity: in the north of the basin during the Phoenician occupation and the nineteenth century mining boom and in the south during the Nazarene period. Periods of over-use and degradation necessitated subsequent contraction and regeneration. Use of the whole basin as the unit of analysis would be to miss out on the fine detail of successive socio-natural systems.

The demographic estimates proposed in this article identify four periods when regional population ‘peaked’ and then declined. With the exception of the earliest peak, in the Argaric Bronze Age c. 2250–1500 cal BC, immigration by colonial powers or resettlement for the purpose of exploitation of the basin’s agricultural and mineral resources were the main determinants of population increase. All four demographic peaks were associated with stratified political systems which dominated the economic activities of the basin. In all cases, the peaks were followed by population declines, associated with a combination of political instability, whether internally or externally generated, and environmental degradation. It is noticeable that the population declines after the late Roman and nineteenth century peaks were more, and increasingly, abrupt than those noted for the second halves of the second and first millennia BC. As with the periods of population increase, growth and decline of population can occur over a longer time-scale than that of individual political systems. In addition, it can be argued that the effects of environmental exploitation were greater at each stage, and that the effects of degradation were more severe and required more ‘recovery’ time.

Although there are good reasons to criticize the use of the term ‘degradation’, given the implications for an original state of equilibrium (Castro et al. 1994), it is widely used in the literature on desertification (see earlier) to refer to ‘reduction
and loss of the biological or economic productivity caused by land-use change, from a physical process, or a combination of the two' (Thornes 1996:1–2). Following this usage, what do the main results of interdisciplinary projects such as Archaeomedes and Aguas tell us about degradation in the Vera basin since 4500 cal BC?

Soils themselves seem to have been of limited formation in the Aguas valley since the early Holocene, before the first agricultural settlement in the basin (French et al. 1998:49). There were even phases of soil erosion before the Copper Age (c. 3000 BC), when the low population density makes an anthropogenic cause unlikely. Other erosional episodes are known from later prehistory, as at Las Pilas (French et al. 1998:49), and further up the Aguas valley at Cadimar (erosion of Neogene marls before the Roman occupation of the site – Castro et al. 1994:53). Prehistoric vegetation degradation is traced through pollen and charcoal analyses (Castro et al. 1994; Castro et al. 1998:62–68; Gale 1999) and in response to expansive cultivation systems and the need for timber during the Copper and Bronze Ages. A marked increase in forest exploitation is observed in the Bronze Age sequence at Gatas, as is the removal of open deciduous and evergreen woodland and maquis at low and middle altitudes. It is proposed that the extensive monocropping of the Argaric period would have led to soil degradation by the middle of the second millennium BC. In the north of the basin, large-scale deforestation took place as a result of Phoenician and Roman mining activities. Like their predecessors, the Romans exported the minerals but in addition exported grain from more intensive agricultural production throughout the Vera basin.

The period of Moorish conquest and occupation of the Vera basin was the exception to this story of over-exploitation. The gravity flow irrigation terraces in the sierras, and horticulture and arboriculture in the valley bottom, were ‘environmentally friendly’ cultivation systems, which did not result in any major clearance or soil erosion. Production was in the hands of more or less self-sufficient, autonomous farmers, rather than directed by external political and economic forces.

It was the abandonment of this agricultural and settlement system at the Christian reconquest, followed by the population growth and extensive exploitation of increasingly poor agricultural land in the eighteenth and nineteenth centuries AD, not to mention the mining ‘boom’ of the latter period, which caused the most serious phase of soil degradation. In his studies of soil erosion and coastal formation in the three valleys of the Vera basin, Hoffman (1988) estimates that as much sedimentation has taken place in the mouths of these valleys during the last 500 years as in the whole of the Holocene. What were estuaries and seasonal marshes in later prehistory are now flat, dry, sediment-filled coastlines. Two of the four Holocene terraces in the river Aguas also date to this period of time, and lend support to Hoffman’s calculations of post-Moorish sedimentation rates (Castro et al. 1998; cf, for the river Antas, Schulte 1995). The occurrence of the so-called ‘Little Ice Age’ at the same time as this intensified erosion makes it difficult to disentangle the roles played by climatic and anthropogenic factors. In the north of the basin, excavations outside the Copper Age settlement of Almizaraque showed that over 1m of sediments had been deposited since the last century, as a result of intensive mining activity and intensive exploitation of the sierras.
THE LONG-TERM AND FUTURE POLICY

Since the 1960s, the Vera basin has been undergoing 'a move towards the artificialization of the landscape – a landscape of increasing technological dependency and economic subsidy' (Castro et al. 1994:310). This move has been determined by the expansion of tourism along the coast and Spain's membership of the European Union. In both cases the markets are external to the region. The realignment of local labour coincides with the decline in ecological diversity, with the abandonment of mountain terrace systems and lowland fields, the monocropping of tomatoes under plastic greenhouses and the canalization of water courses to direct water into aquifers for both the tourist industry and the greenhouses. These trends pose perhaps the most severe problems for the sustainability of the basin since human occupation began. We are in a new phase of exploitation and extraction by external forces.

We fully recognize the importance of research by environmental scientists on current processes of degradation in south-east Spain. The modelling of projects like MEDALUS, based on small-scale (both temporal and spatial) observations, is essential to an understanding of the complexities of erosional processes. But we argue that future policy for the economy and settlement of regions such as the Vera basin should not be based solely on the short-term but should rather incorporate the historical context of long-term change in specific socio-natural systems. This means that the social exploitation of nature is placed at the centre of analysis. In the case of the Vera basin, the archaeo-ecological and historical records trace degradation, as defined by environmental scientists, taking place before major settlement, as well as in response to political decisions of exploitation. Major phases of population growth have been responses to, rather than determinants of, political action, although this has not been invariable, as with the overall lack of population growth for the Moorish occupation in the basin. Environmental 'perturbations' have varied in scale but have been 'sustainable', as long as diversity is maintained and time and space allowed for recovery. These 'rebound' periods may be as long as the millennia during which no exploitation is traced in the lower Almanzora or Aguas valleys. At each stage of exploitation, the ensuing scale of ecological collapse appears to have been more rapid and more long-lasting in its effects. Apart from the Neolithic, the most sustainable period in the basin's history was from the eighth to the sixteenth centuries AD, when the diversity of Moorish agricultural practices can be viewed more as management than exploitation. With the exception of the Argaric Bronze Age, when monocropping proved unsustainable – surely a lesson for the present day! – exploitation has been dependent on external markets, with all their risks of economic and political collapse.

With regard to the Aguas valley, we have distinguished more and less 'aggressive' strategies for the management of the local environment, based on analysis of the long-term (Castro et al. 1998:88). Central to our policy recommendations for this part of the Vera basin were the reactivation of traditional terraced irrigation systems in the sierra Cabrera, the regeneration of the valley bottoms for floodplain farming as a result of the increase in the water table, and the introduction of more local,
democratic systems of water management. The irrigated terraces of the sierra counteracted erosion and water loss, and their abandonment in the 1970s led to a lowering of the water table and a further aridization of the lowlands. The key here is the focus on water conservation and consumption, especially in the context of global warming: the current predicted temperature rise for the Mediterranean basin is $3 \pm 1.5 \degree C$ by the mid-twenty-first century AD, giving an annual increase of 200mm in potential evapotranspiration, increased wildfires and increased wind and water erosion (Le Houérou 1992). Current consumption of water in south-east Spain is at, or above, the sustainable limit of availability. For example, in the Campo de Dalías, in southern Almería, the owners of 11,000 hectares of plastic greenhouses have benefitted from government policies which have given them cheap water supplies, but have created an annual water deficit of 21 million m$^3$ and space in the aquifer for an invasion of salt water (Chabart et al. 1996:394). Such marine intrusions have been documented in other areas of the coast of eastern and southern Spain (Lumsden 1992:268–271). Once again, wealth creation by the few for an external market has led to degradation for the whole catchment. In this context, the prediction of an increase in drip irrigation and greenhouse farming in the Mediterranean under global warming, provided that their growth is controlled (Le Houérou 1992), suggests the further spread of such degradation in the twenty-first century.

Based on analysis of the long-term, our proposals for a reactivation of traditional water-harvesting techniques for the Aguas and the Vera basin as a whole also find support in wider discussions of ‘non-structural’ measures to cope with lowland flooding in the Mediterranean. Rather than canalize the lowlands, Poesen and Hooke (1997:186–191) propose that canalization be removed, given the ‘recognition that rivers in their natural state have a greater ability to adjust to a range of natural events’, and traditional techniques such as ‘boqueras’ (check dams across river beds for diverting floodwaters onto cultivated areas) and ‘acequias’ (small channels for conveying water to irrigated fields) be reinstated. But such proposals, with their implications for naturally-regulated floodplains and renewed coastal lagoons and wetlands, fly in the face of the trends of landscape exploitation since the 1960s. Long-term analysis clearly demonstrates the problems created by continued and intensified exploitation for external markets, rather than investment in, and management of, the local landscape. It is the responsibility of those of us who work in the historical sciences to go beyond our academic boundaries and argue the relevance of their pasts to the present and the future.

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REFERENCES


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The authors are part of a research group that has worked for years on different periods of the later prehistory of south-east Spain and the Balearic Islands. Their interdisciplinary projects have included the excavation and analysis of the archaeological sites of Gatas (Almería), Son Fornés and Son Farragut (Mallorca), and the Cova des Carritx and the Cova des Mussol (Menorca), as well as regional projects on long-term palaeoecological and socio-economic change in the Vera basin, Almería. They have used historical materialism and materialist feminism for research on different areas of methodology and the integration of theory, methodology and archaeological data.

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ABSTRACTS

Archéologie et désertification dans le bassin Vera (Almería, Espagne du sud-est)
Pedro Castro et al.

Les modèles de prédiction d’un réchauffement climatique global et le travail de terrain des scientifiques de l’environnement sur la désertification dans la Méditerranée, se sont concentrés sur le court terme. On démontre dans cet article que la collaboration entre les sciences historiques, tout spécialement l’archéologie, et les sciences de l’environnement peut produire un modèle à plus long terme de la désertification du bassin méditerranéen. Une telle collaboration a récemment pris place avec le soutien financier de l’Union européenne dans le bassin de Vera (Almería, Espagne du sud-est). Les séquences d’occupation archéologiques et historiques sont présentées en détail et sont suivies par une étude des tendances démographiques générales, des occupations humaines et des systèmes politiques de 4,000 BC jusqu’à nos jours. Ceci est suivi de l’étude détaillée de la dégradation à long terme de l’environnement du bassin de Vera. En conclusion, cet article propose l’utilisation de longues séquences pour la gestion future du paysage.

Archäologie und Wüstenbildung in der Ebene von Vera (Almería, Südostspanien)
Pedro Castro et al.


Arqueología y desertificación en la depresión de Vera (Almería, sudeste de España)
Pedro Castro et al.

Las investigaciones sobre el terreno y los modelos predictivos sobre calentamiento global y desertificación en el ámbito mediterráneo suelen estar relacionados con estudios sobre fenómenos acaecidos en un breve lapso de tiempo. En este artículo se argumenta que la colaboración entre las ciencias históricas, especialmente la arqueología, y las ciencias medioambientales puede proporcionar una perspectiva a más largo plazo sobre la desertificación en el Mediterráneo. Esta colaboración ha tenido lugar recientemente en la Depresión de Vera (Almería, sureste de España), en el marco de un proyecto de investigación financiado por la Unión Europea. En primer lugar, se detalla la secuencia de la ocupación humana en la Depresión a partir de datos arqueológicos e históricos. A continuación, se presentan las principales tendencias en cuanto a demografía, asentamientos y sistemas sociales entre 4000 antes de nuestra era y la actualidad. Ello se acompaña de datos sobre degradación ambiental en la Depresión de Vera correspondientes a una amplia temporalidad. El artículo finaliza con una serie de recomendaciones dirigidas a la futura gestión de esta comarca.