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By Charles French, Chris O. Hunt, Reuben Grima, Rowan McLaughlin, Simon Stoddart & Caroline Malone

Volume 1 of Fragility and Sustainability – Studies on Early Malta, the ERC-funded *FRAGSUS Project*

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FRAGSUS

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SEVENTH FRAMEWORK PROGRAMME

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On the cover: *View towards Nadur lighthouse and Għajnsielem church with the Gozo Channel to Malta beyond, from In-Nuffara (Caroline Malone).*

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Preface and dedication

Caroline Malone

The *FRAGSUS Project* emerged as the direct result of an invitation to undertake new archaeological fieldwork in Malta in 1985. Anthony Bonanno of the University of Malta organized a conference on 'The Mother Goddess of the Mediterranean' in which Colin Renfrew was a participant. The discussions that resulted prompted an invitation that made its way to David Trump (Tutor in Continuing Education, Cambridge University), Caroline Malone (then Curator of the Avebury Keiller Museum) and Simon Stoddart (then a post-graduate researcher in Cambridge). We eagerly took up the invitation to devise a new collaborative, scientifically based programme of research on prehistoric Malta.

What resulted was the original Cambridge Gozo Project (1987–94) and the excavations of the Xagħra Brochtorff Circle and the Għajnsielem Road Neolithic house. Both those sites had been found by local antiquarian, Joseph Attard-Tabone, a long-established figure in the island for his work on conservation and site identification.

As this and the two other volumes in this series report, the original Cambridge Gozo Project was the germ of a rich and fruitful academic collaboration that has had international impact, and has influenced successive generations of young archaeologists in Malta and beyond.

As the Principal Investigator of the *FRAGSUS Project*, on behalf of the very extensive *FRAGSUS* team I want to dedicate this the first volume of the series to the enlightened scholars who set up this now 35 year-long collaboration of prehistoric inquiry with our heartfelt thanks for their role in our studies.

We dedicate this volume to:

Joseph Attard Tabone
Professor Anthony Bonanno
Professor Lord Colin Renfrew

and offer our profound thanks for their continuing role in promoting the prehistory of Malta.

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For Chapter 6, Reuben Grima wrote the first draft of this contribution, receiving comments and additions from the other authors.

For Chapter 7, Simon Stoddart wrote the first draft of this contribution, receiving comments and additions from the other authors.

For Chapter 9, we thank Sharlo Camilleri for providing us with a copy of the GIS data produced by the MALSIS (MALtese Soil Information System) project. We are grateful to Prof. Saviour Formosa and Prof. Timmy Gambin, both of the University of Malta, who facilitated the donation of LiDAR data, together with computer facilities, as part of the European project ERDF156 *Developing National Environmental Monitoring Infrastructure and Capacity*, from the former Malta

Environment and Planning Authority. A number of individuals were happy to share their recollections of shepherding practices in Malta and Gozo over the last sixty or seventy years; others facilitated the encounters. We are grateful to all of them: Charles Gauci, Grezzju Meilaq, Joseph Micallef, Louis Muscat, Ċettina and Anġlu Vella, Ernest Vella and Renata Zerafa.

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Firstly, the FRAGSUS Project is the result of a very generous research grant from the European Research Council (Advanced Grant no' 323727), without which this and its two partner volumes and the research undertaken could not have taken place. We heartily thank the ERC for its award and the many administrators in Brussels who monitored our use of the grant. The research team also wants to record our indebtedness to the administrators of the grant within our own institutions, since this work required detailed and dedicated attention. In particular we thank Rory Jordan in the Research Support Office, Stephen Hoper and Jim McDonald – CHRONO lab, and Martin Stroud (Queen's University Belfast), Laura Cousens (Cambridge University), Glen Farrugia and Cora Magri (University of Malta), the Curatorial, Finance and Designs & Exhibitions Departments in Heritage Malta and Stephen Borg at the Superintendence of Cultural Heritage. Finally, we thank Fr. Joe Inguanez (Emeritus Head of Department, Department of Sociology, University of Malta) for offering us the *leitmotif* of this volume while a visiting scholar in Magdalene College, Cambridge: '*Mingħajr art u ħamrija, m'hemmx sinjorija*' translating as 'without land and soil, there is no wealth'.

Foreword

Anthony Pace

Sustainability, as applied in archaeological research and heritage management, provides a useful perspective for understanding the past as well as the modern conditions of archaeological sites themselves. As often happens in archaeological thought, the idea of sustainability was borrowed from other areas of concern, particularly from the modern construct of development and its bearing on the environment and resource exploitation. The term sustainability entered common usage as a result of the unstoppable surge in resource exploitation, economic development, demographic growth and the human impacts on the environment that has gripped the World since 1500. Irrespective of scale and technology, most human activity of an economic nature has not spared resources from impacts, transformations or loss irrespective of historical and geographic contexts. Theories of sustainability may provide new narratives on the archaeology of Malta and Gozo, but they are equally important and of central relevance to contemporary issues of cultural heritage conservation and care. Though the archaeological resources of the Maltese islands can throw light on the past, one has to recognize that such resources are limited, finite and non-renewable. The sense of urgency with which these resources have to be identified, listed, studied, archived and valued is akin to that same urgency with which objects of value and all fragile forms of natural and cultural resources require constant stewardship and protection. The idea of sustainability therefore, follows a common thread across millennia.

It is all the more reason why cultural resource management requires particular attention through research, valorization and protection. The *FRAGSUS Project* (Fragility and sustainability in small island environments: adaptation, cultural change and collapse in prehistory) was intended to further explore and enhance existing knowledge on the prehistory of Malta and Gozo. The objective of the project as designed by the participating institutional partners and scholars, was to explore untapped field resources and archived archaeological material from a number of sites and their landscape to answer questions that could be approached with new techniques and methods. The results of the *FRAGSUS Project* will serve to advance our knowledge of certain areas of Maltese prehistory and to better contextualize the archipelago's importance as a model for understanding island archaeology in the central Mediterranean. The work that has been invested in *FRAGSUS* lays the foundation for future research.

Malta and Gozo are among the Mediterranean islands whose prehistoric archaeology has been intensely studied over a number of decades. This factor is important, yet more needs to be done in the field of Maltese archaeology and its valorization. Research is not the preserve of academic specialists. It serves to enhance not only what we know about the Maltese islands, but more importantly, why the archipelago's cultural landscape and its contents deserve care and protection especially at a time of extensive construction development. Strict rules and guidelines established by the Superintendence of Cultural Heritage have meant that during the last two decades more archaeological sites and deposits have been protected in situ or rescue-excavated through a statutory watching regime. This supervision has been applied successfully in a wide range of sites located in urban areas, rural locations and the landscape, as well as at the World Heritage Sites of Valletta, Ġgantija, Ħaġar Qim and Mnajdra and Tarxien. This activity has been instrumental in understanding ancient and historical land use, and the making of the Maltese historic centres and landscape.

Though the cumulative effect of archaeological research is being felt more strongly, new areas of interest still need to be addressed. Most pressing are those areas of landscape studies which often become peripheral to the attention that is garnered by prominent megalithic monuments. *FRAGSUS* has once again confirmed that there is a great deal of value in studying field systems, terraces and geological settings which, after all, were the material media in which modern Malta and Gozo ultimately developed. There is, therefore, an interplay in the use of the term sustainability, an interplay between what we can learn from the way ancient communities tested and used the very same island landscape which we occupy today, and the manner in which this landscape is treated in contested economic realities. If we are to seek factors of sustainability in the past, we must first protect its relics and study them using the best available methods in our times. On the other hand, the study of the past using the materiality of ancient peoples requires strong research agendas and thoughtful stewardship. The *FRAGSUS Project* has shown us how even small fragile deposits, nursed through protective legislation and guardianship, can yield significant information which the methods of pioneering scholars of Maltese archaeology would not have enabled access to. As already outlined by the Superintendence of Cultural Heritage, a national research agenda for cultural heritage and the humanities is a desideratum. Such a framework, reflected in the institutional partnership of the *FRAGSUS Project*, will bear valuable results that will only advance Malta's interests especially in today's world of instant e-knowledge that was not available on such a global scale a mere two decades ago.

FRAGSUS also underlines the relevance of studying the achievements and predicaments of past societies to understand certain, though not all, aspects of present environmental challenges. The twentieth century saw unprecedented environmental changes as a result of modern political-economic constructs. Admittedly, twentieth century developments cannot be equated with those of antiquity in terms of demography, technology, food production and consumption or the use of natural resources including the uptake of land. However, there are certain aspects, such as climate change, changing sea levels, significant environmental degradation, soil erosion, the exploitation and abandonment of land resources, the building and maintenance of field terraces, the rate and scale of human demographic growth, movement of peoples, access to scarce resources, which to a certain extent reflect impacts that seem to recur in time, irrespectively of scale and historic context.

Anthony Pace
Superintendent of Cultural Heritage (2003–18).

Chapter 11

Conclusions

Charles French, Chris O. Hunt, Michelle Farrell, Katrin Fenech, Rowan McLaughlin, Reuben Grima, Nicholas C. Vella, Patrick J. Schembri, Simon Stoddart & Caroline Malone

There is now a large degree of synergy exhibited by the various classes of palaeoenvironmental data investigated through the *FRAGSUS Project* on Malta and Gozo and the direct inter-linkages and associations of aspects of the environment with human activities during the last 8000 years. The geological setting and well dated palynological, molluscan and soil/sediment data present a background picture of vegetational and landscape change throughout the Holocene, with some very specific data on trajectories of clearance, erosion and farming activities in various valleys of the Maltese landscape. Nested within this broader framework, there is an immense amount of more specific data on the development of and changes in palaeosols, the frequencies and types of soil erosion and formation of valley fill sequences, as well as the dynamics of near-shore, valley and plateaux landscapes through prehistoric and historic times in both Malta and Gozo. Within these, there is an exceptional amount of data concerning the impacts of the first farming communities and the resilience of these island landscapes during the Neolithic period between the seventh and third millennia BC. The following summative interpretational sections attempt to draw out the main themes and trajectories of landscape change that have occurred during the Holocene in the Maltese archipelago.

11.1. The palynological record

Chris O. Hunt & Michelle Farrell

The intensive palynological and molluscan analyses of a number of deep core sites at Salina, Marsa, Xemxija, and Wied Żembaq, along with new pollen and soil micromorphological evidence from Neolithic palaeosols at the Santa Verna, Ġgantija and Skorba temple sites, and complementary existing palynological data from Salina Bay, Marsa and Santa Marija (Carroll *et al.* 2012), Burmarrad (Djamali *et al.* 2013; Gambin *et al.* 2016) and Tas-Silġ (Hunt 2015) have provided well dated and detailed sequences of vegetational and landscape change throughout the last 9000 years of the Holocene (Table 11.1; Figs. 11.1 & 11.2). Not only do the analyses of the cores provide evidence for vegetation and landscape change from before the Neolithic period, but they reflect both anthropogenic impacts from land-use and climatic changes in the same records. In combination with the molluscan and palaeosol records, we now have unparalleled detail on the nature of human impacts over the *longue durée* on the Maltese Islands.

11.1.1. Climate

The climate of Malta has been affected by significant regional climate events, notably the 8.2 ka BP desiccation. In contrast, later events and their impacts are more muted in comparsion with their magnitude and effects elsewhere in the Mediterranean Basin. The 6.5 ka BP event hardly registers in the palynological record and the 4.3 ka BP event is equivocal in its signal, possibly suggesting a short period of lower effective moisture. Against a generally rather arid earlier Holocene, short phases of relatively high effective moisture occurred at approximately 6650–6550 cal. BC (8600–8500 cal. BP), 6350–6200 cal. BC (8300–8150 cal. BP) and 5650–5500 cal. BC (7600–7450 cal. BP). The episode at 6350–6200 cal. BC (8300–8150 cal. BP) is a regional event, widely visible in palaeoenvironmental records from the arid western and central Mediterranean lowlands (e.g. Reed *et al*. 2001; Tinner & Lotter 2001; Tinner *et al.* 2009), but the other two are more localized. This episode is followed by a very dry period coincident chronologically with the 8.2 ka BP event (Alley *et al*. 1997). This is a short episode of significant aridity that appears to have occurred at many localities in the central Mediterranean (Tinner *et al.* 2009; Sadori *et al*. 2013, 2016; Magny *et al*. 2009, 2011; Jaouadi *et al.* 2016).

Around 4970 cal. BC (6920 cal. BP) there is a profound reorganization of moisture regimes in the Maltese Islands and more widely in the arid western

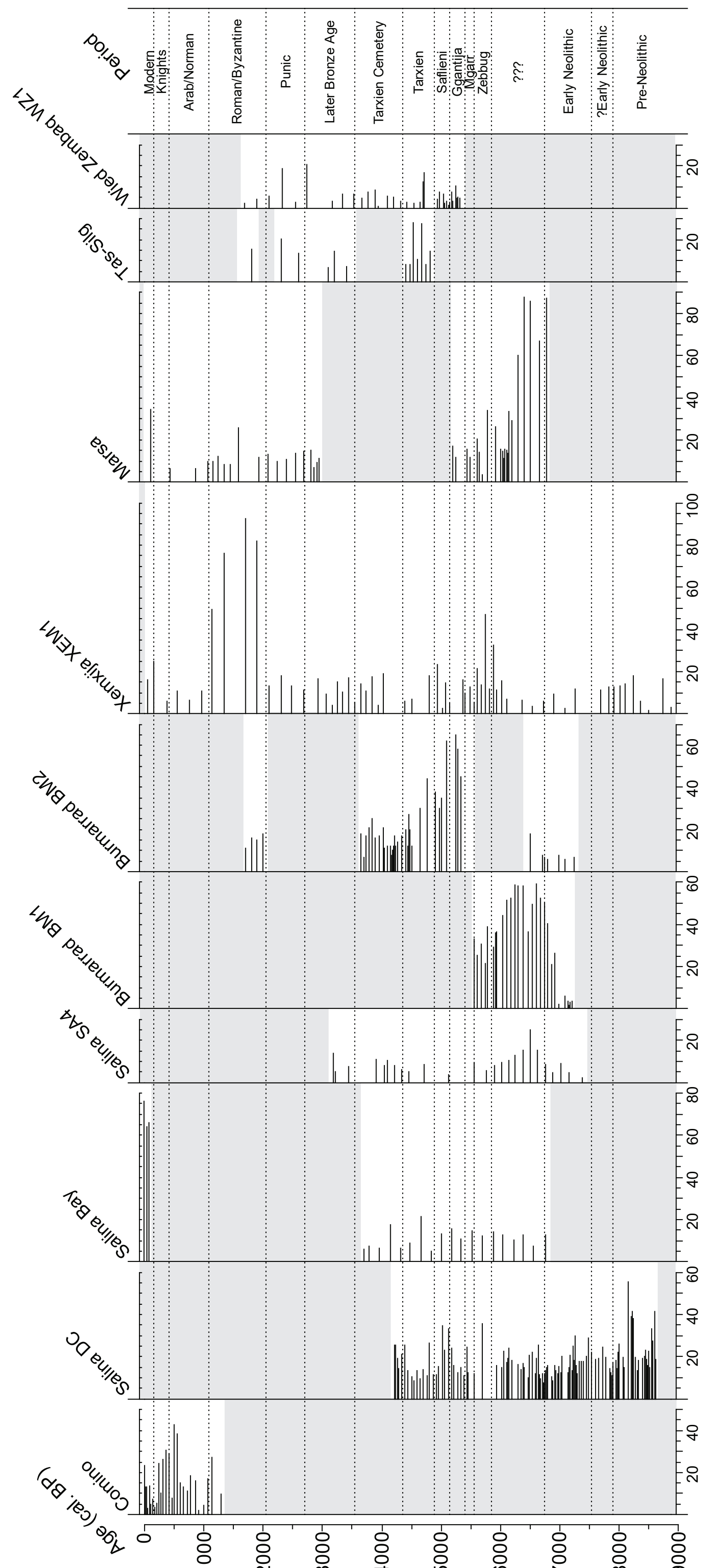

Figure 11.1. *Summary of tree and shrub pollen frequencies at 10 sample sites (C.O. Hunt).*

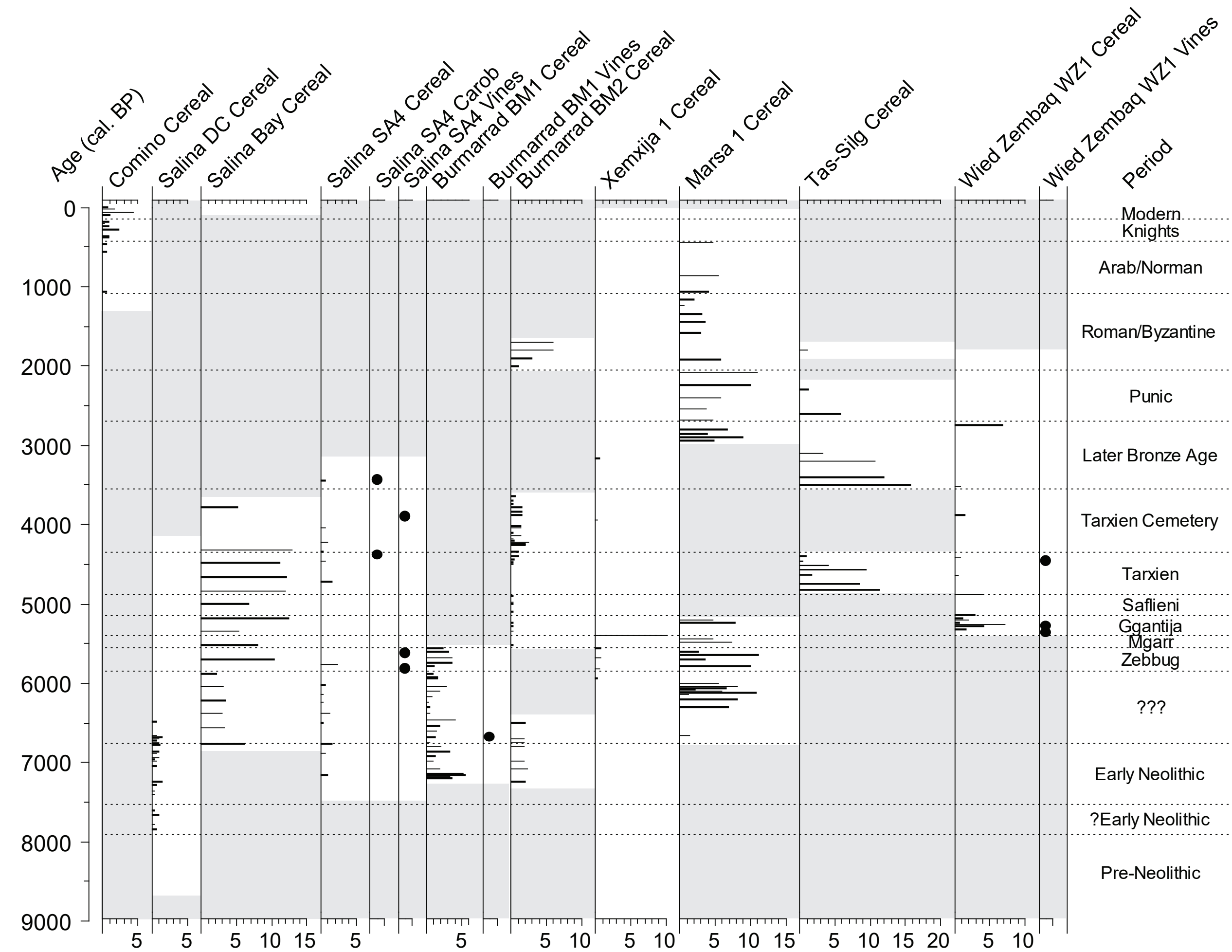

Figure 11.2. *Summary of cereal pollen frequencies at 14 sample sites (C.O. Hunt).*

and central Mediterranean coastal regions, caused by weakening African monsoonal circulation and thus greater regional incursions of moisture-bearing Atlantic air masses (Tinner *et al.* 2009; Bini *et al.* 2018). In the Maltese Islands, this is manifested by the growth of dense scrub in low-lying areas where intensive agriculture was not practised, most notably at Burmarrad (Djamali *et al*. 2013), but also at Marsa (Carroll *et al.* 2012) (Fig. 11.1). The effective humidity remained relatively high in the Maltese Islands until approximately 3050 cal. BC (5000 cal. BP), when more generally arid conditions began to prevail. Within this period of generally higher effective humidity, there seem to have been periods of especially high moisture at 4750–4250 cal. BC (6700–6200 cal. BP) and 3450–3050 cal. BC (5400–5000 cal. BP).

Following the onset of more arid conditions *c*. 3050 cal. BC (5000 cal. BP), there was a further short humid episode at 2850–2650 cal. BC (4800–4600 cal. BP). The next major climatic event in the Mediterranean around 2350–2250 cal. BC (4300–4200 cal. BP) (e.g. Sadori *et al*. 2013; Jaouadi *et al*. 2016; Ruan *et al*. 2016; Bini *et al*. 2018) is marked in the Salina Deep Core by rising *Pistacia* (lentisk scrub), but this is not a general trend and it is not clear whether this marks a relaxation of agricultural pressure at this one site (cereal pollen falls at this point in nearly all cores, but elsewhere tree and shrub pollen percentages do not rise) or a climatic response to rising humidity. There is, however, no convincing evidence for aridification in the available pollen records from Malta, but there is evidence for a gradual trend of aridification over the *c*. 400 years before, with generally falling tree pollen curves (Fig. 11.1). Thereafter, there is no strong evidence for periods of enhanced effective humidity, other than the possibility of a minor episode much later in the Little Ice Age. It must be remarked, however, that the later Holocene in the Maltese Islands was characterized by

Table 11.1. *Summary of environmental and vegetation change in the Maltese Islands over the* longue durée.

Chronology cal. BC/AD	Years BP	Environmental history
7500–5900 BC	9450–7850	The Maltese Islands were covered by grassy steppe with patches of scrub and a few trees, mostly oaks and pines. At times 6650–6550 cal. BC (8600–8500 cal. BP) and 6350–6200 cal. BC (8300–8150 cal. BP) the climate was wetter than at present, causing lentisk scrub and Mediterranean woodland to spread, but around 6550 and again at 6200 cal. BC the climate became much drier, each time for about 200 years, causing the scrub and woodland to die back. Sea level was rising rapidly and so the Maltese landmass was shrinking.
5900–5400 BC	7850–7350	People arrived with grazing animals around 5900 cal. BC, burnt much of the natural vegetation around their settlements (scrub at Burmarrad and open pine-juniper scrub woodland at Marsa) and started small garden-like cereal plots to grow barley and some wheat. Early cultivation caused soil degradation and erosion, so people shifted their cultivation plots every few years. Cultivation, grazing, burning and drought caused severe soil erosion, particularly around Marsa, the Burmarrad Plain and Xemxija. The uncultivated land was still predominantly grassy steppe. Sea level continued to rise.
5400–5200 BC	7350–7150	Grazing intensified and at this point the grassland started to degrade, with ruderals (weeds) beginning to replace steppic vegetation. Cereal use became generally more intensive and intense soil erosion continued, probably because of grazing pressure. It became a little drier. Sea level rise slowed.
5200–4800 BC	7150–6750	Olives appear in the pollen record, and barley cultivation expanded. The grazed land continued to degrade. The climate became substantially wetter allowing scrub and woodland to spread where human impact was still low, for instance around the large alluvial plains at Xemxija and Burmarrad.
4800–3900 BC	6750–5750	Sea level rise slowed. Humidity was generally relatively high but there was a pattern of environmental instability probably caused by human impact, as scrub at Burmarrad and Mediterranean woodland at Marsa declined, with evidence for substantial burning at Marsa. *Vitis* appears at Burmarrad at the beginning of this period. Woodland seems to have expanded at Xemxija. There were low levels of cereal cultivation, except at Marsa where cereal cultivation became prominent.
3900–2350 BC	5750–4250	Substantial but patchy cultivation of wheat, barley, perhaps some olives and grapes, the latter appearing at Salina and a little later at Wied Żembaq. The exception seems to have been in the Burmarrad lowland where woodland remained prominent. Grazing pressure caused the gradual replacement of grassy scrub by a ruderal flora. Woodland came and went in the landscape, at Xemxija, Salina, Wied Żembaq and Tas-Silġ, perhaps suggestive of some sort of rotational land use at these sites. Sea level rise slowed further.
2350–2000 BC	4250–3950	Humidity declined, with severe droughts, especially at the start of the period. Cereal cultivation ended except at Burmarrad, where it seems to have started. Grazing may have continued and ruderal vegetation flourished.
2000–1000 BC	3950–2950	Patchy cultivation of cereals, vines and possibly olives. Grazed areas had very degraded vegetation. Humidity remained fairly low and it is likely that droughts remained common.
1000 BC–AD 100	2950–1850	Widespread cultivation of cereals, vines and olives with very degraded grazed lands and much soil erosion. Humidity probably remained relatively low.
AD 100–400	1850–1550	Very widespread cultivation of vines, olives and cereals with grazed lands dominated by ruderal flora. Intense soil erosion. Humidity probably remained fairly low. During this period a pine plantation was established at Xemxija.
AD 400–1550	1550–400	Very degraded landscape with some cereals and olives. The pine plantation at Xemxija was cut down around cal. AD 800–900. Humidity was probably very low and irregular with marked declines around cal. AD 1100, 1300 and 1500.
AD 1550–1800	400–150	Gozo had grassy landscapes with widespread sheep-runs. Cereal cultivation became more important on Malta and Comino with terracing under the Knights, and cotton became an important cash crop. Humidity may have increased somewhat, but declined towards the end of the period.
AD 1800–present	150–present	Cereal cultivation became more important. Pines and eucalyptus were introduced in the late nineteenth century. Non-cultivated landscapes were highly degraded. Humidity may have recovered somewhat.

extremely resilient anthropogenically degraded vegetation under severe pressure that may have suppressed any marked response to climate change.

11.1.2. Farming and anthropogenic impacts on vegetation
From the extensive data gathered by the *FRAGSUS Project*, there is no convincing evidence for human impact on vegetation in the pollen record prior to the first traces of cultivation provided by pollen of wheat and barley, and coprophilous fungal spores providing evidence for livestock grazing, which occur at *c*. 6067–5971 cal. BC (8017–7921 cal. BP). The initiation of farming likely followed the arrival of people using Neolithic technology, relating to the well known Neolithic diaspora into the western Mediterranean (Ammerman & Cavalli-Sforza 1984; Malone 1997–8, 2003, 2015; Whittle 1996; Zilhão 2001). As such, this date is slightly later than the first Neolithic dates in southeast Italy, but is earlier than those for all known Neolithic sites further west (Zeder 2008). Thus, it is possible that the Maltese Islands were a key staging post in this diaspora. As yet, no archaeological evidence in Malta or Gozo corroborates these findings, but if the first settlements were coastal, they must now lie beneath some 20 m of sediment and water.

After the first appearance of cereal pollen in the Salina Deep Core about 7950 years ago, it is represented virtually continuously in at least one pollen diagram until the present day (Fig. 11.2). It is clear, however, that during the earlier Neolithic there were cyclic changes in the cereal curves, with generally low cereal pollen percentages, which suggests more or less small-scale, shifting arable activity. Initial cereal cultivation, visible only in the Salina Deep Core, was of both barley and wheat, but wheat cultivation seems to have been generally less widespread and is less frequently recorded in the Early Neolithic than barley. This may reflect the ability of barley to cope well with seasonal aridity, in what must have been a relatively dry landscape, at least seasonally. Falling biodiversity of crop plants following first farming occurred widely in the western Mediterranean (de Vareilles *et al.* 2020) as agriculturalists adapted to localized conditions.

Around 5550 cal. BC (7500 cal. BP), grazing became more intensive. It intensified further and peaked around 5350–5050 cal. BC (7300–7000 cal. BP), as did cereal cultivation, suggesting that this episode may have been a time of relatively high population engaged in both arable and pastoral farming that began the opening-up of the Maltese and Gozitan landscapes. There may have been active localized clearance of vegetation to facilitate farming. Recent corroboration of this type of impact has been found in a deep core from Marsa by Marriner *et al*. (2019), which shows repeated fire episodes associated with rapid run-off observed in the charcoal and geochemical records between 5650 and 5400 cal. BC (7600 and 7350 cal. BP). Evidence also comes from Burmarrad where rapid sedimentation rates between 5550 and 5350 cal. BC (7500 and 7300 cal. BP) correspond with human-modified vegetational change from forest stands to mixed shrub-grassland (Djamali *et al.* 2013).

Around 5050 cal. BC (7000 cal. BP), a strong rise in *Pistacia* at Burmarrad, with values staying remarkably high until around 2250 cal. BC (4500 cal. BP) (Djamali *et al.* 2013; Gambin *et al.* 2016), may suggest the appearance of a patch of dense lentisk (*Pistacia*) scrub. The expected successional development, with expansion of olive and then oak, did not start for another 2000 years. It is possible that the lentisk patch was a managed resource rather than natural vegetation which would have provided animal fodder, oily fruit/seeds and firewood, all resources likely to have been in relatively short supply in this early agricultural system.

There appears to be a relatively long hiatus in the archaeological record between *c*. 4800 and 3800 cal. BC (6750 and 5750 cal. BP). In contrast, the pollen record shows that after a brief decline in cereal pollen, further peaks of cereals are evident at Salina and Burmarrad close to 4800 cal. BC (6750 cal. BP). At Salina (Carroll *et al*. 2012), this period was followed by continuous high frequencies of cereals and there was a significant peak of cereals at Marsa around 4350–4150 cal. BC (6300–6100 cal. BP). Grazing indicators also remained high at these sites throughout. It is likely, therefore, that there was some sort of population continuity through the apparent archaeological hiatus, and it is hoped that this will be corroborated by further archaeological research. Nonetheless to date, no dated archaeological sites have any representative stratigraphy or artefacts relating to this apparent millennium-long hiatus.

The Later Neolithic (or Temple Period) is marked by very high cereal percentages, notably in the Żebbuġ, Ġgantija and especially the early Tarxien phases of the early to mid-third millennium BC. At Salina Bay the high cereal percentages persist into the end of the Tarxien phase in the mid-third millennium BC (Carroll *et al.* 2012). It is likely that arable agriculture was widely practised and intensive, but diminishing at several locations during the Tarxien phase, possibly in response to aridification and related environmental degradation. The very high percentages of cereal pollen at or close to major archaeological sites may reflect handling or threshing of cereals adjacent to temple sites.

The end of the Neolithic at about 2400 cal. BC (4350 cal. BP), coincident with general abandonment of the temple sites, is marked by a hiatus in cereal cultivation at all sites except at Burmarrad, where cultivation seems to have continued (Gambin *et al.* 2016). Cereal production at this site alone parallels the continued use of cereals at Tas-Silġ through the Early Bronze Age (Fiorentino *et al*. 2012). Grazing and animal husbandry continued at some sites, but may have ended at others as shown by the faunal remains in post-Temple Period cultural levels at Taċ-Ċawla (see Volume 2, Chapter 3). It is possible that along with profound cultural change at this time, populations contracted into the higher land of the Globigerina Limestone plateau on Malta, perhaps in response to coastal raiders (cf. Wiener 2013).

Later in the Early Bronze Age, cereal cultivation seems to have resumed at coastal localities, and this continued into the nineteenth century AD at Marsa (Carroll *et al.* 2012). Evidence from other sites is patchy, partly because assemblages were affected by strong taphonomic biases. Olive groves were important at Marsa in the Punic and Roman periods and at Burmarrad in the Roman Period, and there seems to have been a pine plantation at Xemxija in Roman to early medieval times. These tree crops may not have been completely for consumption on Malta as there was an olive oil trade in the Mediterranean from late Punic times. This expanded in the first and second centuries AD to satisfy demand from Imperial Rome, and Rome was also a voracious market for grain, wine, timber and many other products (Hohlfelder 2008; Margaritis & Jones 2008).

During Medieval times, the Maltese landscape seems to have been extremely degraded, although some cereal cultivation continued. After the mid-sixteenth century, the Knights of St John seem to have started the regeneration of the Maltese landscape through the encouragement of terracing and exploitation of new parts of many valley systems, such as the Ramla valley on Gozo. Crops such as cotton were adopted and grazed grassland seems to have become widespread. Finally, the British and modern periods saw the widespread planting of ornamental trees, especially pines and eucalypts.

11.2. The molluscan record

Katrin Fenech, Chris O. Hunt, Nicholas C. Vella & Patrick J. Schembri

The detailed molluscan analyses of the long cores taken through many of the deep valley sedimentation sequences have provided extensive sets of quite specific palaeoenvironmental data for the Holocene, which augment both the palynological and soil/sediment analytical results. These are summarized in Table 11.2.

From the analysis, four major themes consistently present themselves. The first, is the initial influence of freshwater in the lower reaches of several valleys, just inland from the sea, which continues from at least 4800 cal. BC (6750 cal. BP) into the fourth and third millennia BC of the Neolithic Temple Period. There is evidence of perennial freshwater streams and shallow, marshy areas, with slow to stagnant freshwater and accumulations of abundant leaf litter. These habitats often exhibit considerable variation in spatial extent and frequency of occurrence through time, no doubt reflecting seasonal changes in rainfall and possibly even longer-term climatic trends in terms of greater or lesser rainfall, together with geomorphic changes caused by sedimentation and sea level rise. This is particularly evident in the Xemxija and Wied Żembaq cores. It is certainly possibly that the climate was wetter than today, since this evidence falls within the Holocene Climatic Optimum, evidence for which is also found in nearby Sicily (Carroll *et al*. 2012; Sadori *et al*. 2013). However, by the first millennium BC and certainly by the end of the Roman period, freshwater habitats were in strong decline, and rarely recovered thereafter. Exceptions include the Pwales valley where today a spring is caught in a reservoir.

Second, there were a number of near-shore lagoonal environments with brackish water especially at Salina, Wied Żembaq and Mġarr ix-Xini. These environments persisted from the Temple Period of the later Neolithic and through into the Roman period. These environments would have supported important wild food sources (e.g. fish, fowl, molluscs and shellfish) and would have supplied various kinds of household construction materials (e.g. reeds, grasses, withies). Stable isotope studies suggest these additional food sources were not prominent in the Neolithic diet, although some mollusc shells and bones of fish and fowl occur in archaeological sites of the period.

The third characteristic was the general openness of the landscape, with little sign of densely vegetated environments from the early Holocene onwards. Very few woodland molluscan species were recovered from the cores, and the only definitive occurrence was of *Lauria cylindracea* in the Xemxija 2 core at depths which equate to about 4300–2000 cal. BC. This indicator species had disappeared by *c.* 1800 cal. BC. Before and after that time there are suggestions of leaf litter habitats occasionally being present, but there is very rarely evidence to suggest anything other than ubiquitous open karstland over the *longue durée*.

Fourth is the evidence for continuing landscape degradation from at least the seventh millennium BC onwards. This evidence complements and corroborates the considerable aggradations of eroded soil material observed in most valley systems. Soil erosion was already occurring by the 8.2 ka BP aridification event, and was observed in the base of the Xemxija

Table 11.2. *Summary of events revealed by the molluscan data in the deep cores.*

Chronology cal. BC/AD	Location	Landscape/sediments/erosion	Local vegetation
8000–6000 BC	Xemxija and Salina	Saline marshland, perennial streams, slow moving water and ponds	Open country with quite lush vegetation on margins; open country/ karstland in vicinity
6000–3900 BC	Xemxija and Salina	Receding freshwater bodies; marsh disappearing; landscape instability and droughts; high sedimentation rates	Decrease in leaf litter; open country with grassland, karstland
from 5900 BC	All cores, especially Xemxija, Wied Żembaq and Salina	Soil erosion and aggradation in lower parts of valleys	Open country with sparse vegetation, karstland
3900–2400 BC	Xemxija	Perennial running freshwater stream; slow to stagnant water and pond;	Expansion of saline marshland after *c*. 2930 cal. BC; low leaf litter;
	Salina	Running freshwater and ponds; several episodes of severe erosion and storm events;	Breakdown of vegetative cover associated with agriculture;
	Wied Żembaq	Stream in valley, with saline marsh at valley mouth	Open country/karstland in vicinity
2400–750 BC	Xemxija	Decrease in freshwater habitats, especially of running water;	Light grassland, open country/ karstland; leaf litter occasionally; no woodland snails present past 1800 cal. BC;
	Wied Żembaq	Stream/running water ceases; brackish/ saline marsh continues;	Open country/karstland increases
	Wied Żembaq, Marsa 2 and Mġarr ix-Xini	High energy sedimentation	
750 BC–AD 650	Xemxija	Brief reappearance of freshwater stream; decrease in saline marsh with increased marine influence;	Open country/land species scarce;
	Wied Żembaq	Freshwater input becoming more limited;	Mainly open country/karstland;
	Mġarr ix-Xini	Similar to previous period;	Mainly open country/karstland, with grapevines in Punic period;
	Marsa 2	Declining freshwater with slow/stagnant water;	Scrub and open exposed habitats;
	Marsaxlokk	No freshwater, except possibly seasonally	Mainly open country/karstland
from 750 BC	Wied Żembaq	Freshwater input becoming more limited	Mainly open country/karstland
from AD 800	Xemxija	Erosion and aggradation of pale brown stony soils	Sparsely vegetated open country/ karstland

cores. Nonetheless, the erosion and deposition of soil from the Pwales valley catchment appears to have begun relatively slowly and episodically. Fine eroded soil material associated with a gradual trajectory of degradation that intensified over time is especially evident from the first millennium BC onwards. This sedimentation process probably continued to be driven by prehistoric farming activities in the higher parts of the Maltese landscapes from the sixth millennium BC, a suggestion corroborated by both the palynological and soil micromorphological data. Certainly, molluscan diversity and abundance began to decrease from the end of the Neolithic period, evidence which strongly suggests the increasing and coincident influence of drying and soil and land degradation. The aggradation sequences are occasionally punctuated by evidence of more significant erosion events, related to either storm events from the sea, and/or severe rainfall erosion events generating eroded soil and limestone breccia valley fills from inland.

11.3. The soil/sediment record

Charles French

Geoarchaeological fieldwork and laboratory analyses focusing on the Neolithic temple sites located on the Xagħra plateau and the associated Marsalforn and Ramla valleys on Gozo and the Skorba and Xemxija/Salina/Pwales valley areas of northeastern Malta have suggested a new model of soil development for the early to mid-Holocene (Table 11.3; Fig. 11.3). Well developed, thick, moist and vegetated clay-enriched (or argillic) brown soils (or Orthic Luvisols) with a considerable wind-blown silt component had developed on the Upper Coralline Limestone plateaux and hill-top shoulder areas of the islands from at least the ninth–sixth millennia BC. Similar soils with a greater sand component had probably developed on the Greensand exposures just below the plateaux, and with a greater silt component on the Globigerina Limestone areas, often in the lower parts of the valley systems. There is corroborative evidence for this formerly slightly moister and more vegetated landscape associated with good soil development observed in the palynological and molluscan data, and in particular, the evidence of scrubby open woodland and shallow, slow-moving freshwater streams and marshy areas at several valley locations such as Xemxija in the lower Pwales valley, Wied Żembaq and Ġgantija and the Ramla valley. In contrast, the soils on the intervening Blue Clay geological exposures on the valley slopes were thin and poorly developed organic A horizons over thick, slowly weathered silt and clay-rich subsoils (or Leptosols), but were either just below or associated with springs, many of which are still viable today such as in the Ramla valley immediately south of Ġgantija temple.

The palaeosol records revealed that the reasonably well developed, clay-enriched, brown soils in the upper parts of the valley and mesa plateau landscapes subsequently underwent major soil changes during the mid-Holocene, especially during the Neolithic and Bronze Age periods. The micromorphological analyses clearly showed the combined effects of the impact of Neolithic farming communities on the soil/landscape system from at least the sixth millennium BC, and particularly during the fourth–third millennia BC Temple Period, and subsequently with the increasingly very dry climatic regime. The thick, well structured brown and clay enriched soils (Orthic Luvisols) gradually changed to either red Mediterranean soils (Chromic Luvisols) and/or very thin red calcitic A horizon versions of these soils on the limestone bedrock (or Leptosols), equating with Lang's (1960) 'terra soils' and 'xero-rendzinas,' respectively.

Despite the naturally low base status of these transformed soils, associated with rapid bio-degradation of the near surface organic matter, a degree of agricultural productivity may well have been maintained though the enhancement of the soil's organic content by the deliberate incorporation of household derived organic and artefactual waste. This significant soil management feature appears to have begun in the mid-third millennium BC, certainly at Ġgantija and probably also but slightly earlier at Santa Verna and Skorba. It is possible that deliberate soil enhancement would have improved soil fertility and stability, and as a soil conservation measure, this action may well have underpinned the viability of later Neolithic agricultural society in the Maltese Islands. But whether this soil management was actually the beginning of constructed terraces is much harder to say with any certainty. Moreover, the resilience and agricultural productivity of the wider landscape continued to be evidenced in the palynological record throughout Neolithic and later prehistoric times in terms of the continuing utilization of arable and pastoral landscapes, despite coincident and on-going landscape degradation. This utilization suggests that the landscape's inherent resilience was well understood by the farming population of these islands, but despite that understanding, it remained continually susceptible to soil loss through alternating periods of de-vegetation and aridification, punctuated by high rainfall events. Certainly the substantial thicknesses of valley fills across the islands that accumulated over the last *c*. 9000 years revealed in the coring programme testifies to continuing physical disruption and erosion of most of the valley catchments.

Of course, this new model of soil change in Neolithic times in Gozo and Northern Malta need not have been the soil development trajectory everywhere on the Maltese Islands. Soil changes would have undoubtedly varied locally, dependent upon geology, vegetation, moisture and erosion regimes, human activities and time. Clearly geoarchaeological investigations of each valley/plateau system in Malta and Gozo are desirable, in association with an enhanced programme of OSL and radiocarbon dating to establish reliable chronologies of landscape change. Nonetheless, from what has already been achieved by the *FRAGSUS Project*, there is a strong degree of corroboration between several classes of evidence and events observed in the palynological, molluscan, soil, stratigraphical and chronological records across the islands. Moreover, these confluences of data clearly suggest that seminal models of the setting of monuments now need to be reassessed. It is no longer justifiable to rely on modern soil-type distribution as a guide to the nature of past landscapes.

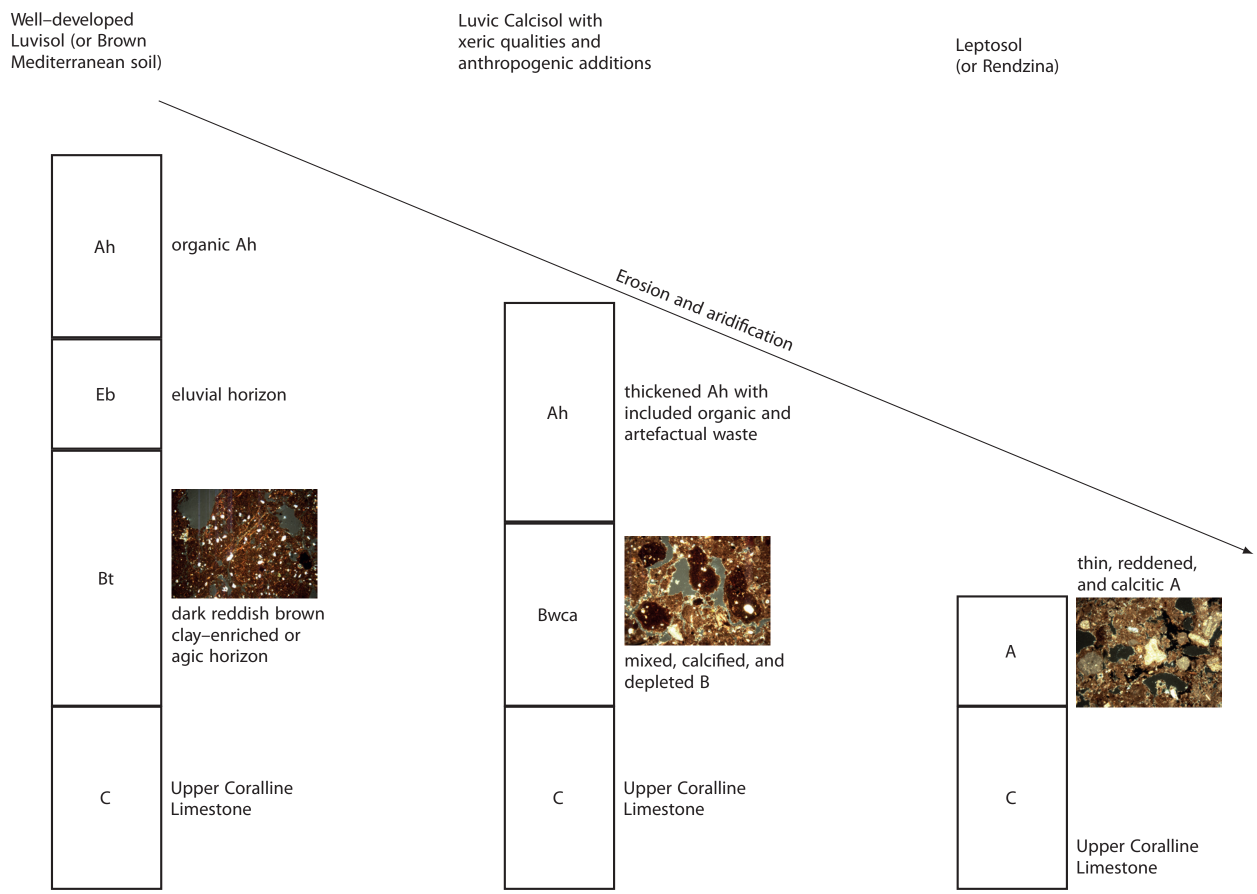

Figure 11.3. *Schematic profiles of possible trajectories of soil development in the major geological zones of Malta and Gozo (C. French).*

With time, the system of prehistoric soil improvement came under inevitable strain. A combination of de-vegetation, sustained human use and a wider coincident aridifying trend led to the formation of either dry, organic-poor, red Mediterranean *terra rossa* soils and/or thin, organic-poor, calcitic soils associated with open xeric landscapes. This coincident set of processes was in-train from at least the early fourth millennium BC onwards, and was well advanced a millennium later, probably making successful arable farming both more intensive but riskier in many parts of the landscape. More specifically, arable farming would have become very difficult to sustain on the Upper Coralline Limestone plateaux, a conclusion that is corroborated by the shrinking evidence for cereal cultivation and an increase in poor pastoral land in the wider palynological record from the third millennium BC onwards.

The aggradation of fine eroded soil was well underway in many of the valleys from the mid-Holocene or the sixth millennium BC. In the base of the Xemxija cores, there is strong evidence for the erosion and aggradation of silt-sized soil-derived material both from just before and during the early Neolithic (seventh to fifth millennia BC). The beginning of this erosional trend could have been triggered at Xemxija by the 8.2 ka BP climatic drought event, but the on-going input of fine eroded soil into the valley bottoms from higher up the valley slopes suggests the continuing destabilizing impact of early and later Neolithic farmers.

More frequently, limestone-rich hillwash accumulations in valley bottoms appear to be a later prehistoric, historic and modern feature of the valley landscapes. In the basal third of the Xemxija 1 core for example, initial erosion appears to have been derived from disruption of the upper parts of the Blue Clay slopes at the transition to the Greensand geology, but subsequently becomes dominated from the Temple Period in the fourth millennium BC by erosion of clay-enriched and carbonate dominated soils derived from the Upper Coralline Limestone plateau. In post-Neolithic times, severe soil erosion and accumulation down-slope

Table 11.3. *Major phases of soil, vegetation and landscape development and change during the Holocene.*

Chronology and location	Vegetation and landscape	Soil and erosion features	Human impact
Earlier Holocene, ninth–seventh millennia BC	Variable to open cover of coniferous scrub and deciduous woodland with lentisk and grassy steppe	Incipient to well developed, moist, humic and stable brown soils with fine silt and clay illuviation and argillic lower Bt horizon formation on Upper Coralline Limestone; thick vertisols in many valleys	Minimal knowledge of earliest Holocene
Early Neolithic, seventh–sixth millennia BC	Open scrub woodland with wild fires; first signs of grasses and herbs increasing and some regression of scrub; perennial streams and marshy areas in lower parts of some valleys	Stable, moist well developed, clay enriched brown soils on Upper Coralline Limestone; first signs of soil erosion of upper valley slopes and aggradation in some valley bottoms	First signs of soil erosion and incremental alluvial aggradation in many valleys from the seventh–sixth millennia BC relating to early clearance and human agricultural interference; e.g. Xemxija and Salina cores
Middle Neolithic, fifth millennium BC	Open, mixed deciduous scrub and grassy steppe; first small wheat/barley plots and grazing animals	Stable, vegetated, well developed, moist, humic, brown soils; continuing signs of soil erosion & aggradation in valley bottoms	Continuing soil erosion moving material from the upper valley slopes and limestone plateaux into valley bottoms
Neolithic Temple Period; from the early fourth millennium BC	Open, deciduous scrub with limited cereal cultivation and more intensive grazing and development of ruderal vegetation	Red-brown soils showing further signs of clearance and drying out with thinning, fines depletion, calcification and rubification, thus becoming transitional reddish brown soils	Upper Coralline Limestone plateaux becoming extensively utilized for settlement, temples, burial and farming; continuing soil thinning and erosion; some marshy areas in lower valley locations
Later Neolithic Temple Period; early–mid-third millennium BC	Scrubby to open with mixed agricultural use with cereals, poosibly olives and vines; turning to dry ruderal dominated garrigue in places with soil erosion; marshy areas in lower valleys drying out and receding	Reddish brown soils becoming more strongly calcified and reddened with secondary iron oxides; in places with signs of amendment of the A horizon with settlement derived organic midden waste material	Continuing extensive utilization; some managed arable fields along upper, southern edge of Upper Coralline Limestone plateaux and poor grazing land on plateaux and valley slopes; continuing soil erosion from the plateaux areas into the valley bottoms
From the Bronze Age; second millennium BC onwards	Ostensibly open, mix of arable cultivation of cereals, vines and olives and ruderal dominated pasture land, with developing garrigue on plateau	Extensive development of thin, dry, depleted, mixed, calcitic red soils on the Upper Coralline Limestone plateaux	Poor grazing and arable land on the Upper Coralline Limestone plateaux; intensifying soil erosion from the plateaux and slope areas into the valley bottoms, especially during 1550–1000 cal. BC
Ramla and Marsalforn valleys throughout prehistoric times	Valley slopes with scrubby woodland and natural springs/ marshy areas	Thick, moisture retentive, silty clay vertisol-like soils in the Blue Clay Ramla valley and fine sandy/silty clay loam hillwash soils in Marsalforn valley	Minimal human impact; possible use of Blue Clay valleys for some pannage for livestock and use of springs and natural raw materials
Marsalforn valley from at least mid-second millennium BC	Clearance, cultivation of vines, olives and cereals and hillwash accumulating in valley bottom; lower valleys now dry	Calcitic silty clay soils with thin A horizons on slopes, prone to overland flow when bare	Extensive utilization and erosion; stop/start hillwash associated with arable use and/ or construction of terraces; but no absolute data on when terracing starts
Ramla valley from medieval times	Scrubby open slopes	Thick, moisture retentive silty clay vertisol-like soils with thin A horizons	Pasture and limited arable use?; use of springs and natural raw materials?
Ramla valley from fifteenth–sixteenth centuries AD	Clearance and field enclosure of grassy landscape; first definite terracing with cereal cultivation becoming more important	Clearance, terracing and stone wall construction leading to reworking, thinning/thickening of soils; prone to summer drying out and some hillwash effects	Establishment of first lanes and terraced field systems by Knights of the Order of St John; general disruption, surface drying and hillwash effects
Plateaux and valleys from the nineteenth century AD	Mix of olive, vines, fruit and cereal cultivation and grazing with some urban development on plateaux	Thin, single horizon, depleted, *terra rossa* and rendzina-like soils on Upper Coralline Limestone; thick to thin, silty clay vertisol-like soils on terraced valley slopes	Extensive mixed agricultural economy with ubiquitous terracing and new urban development on the Xagħra plateau
Plateaux and valleys from the twentieth–twenty-first centuries AD	Mix of olive, vines, fruit and cereal cultivation and grazing, with increasing urban development on plateaux	As above	Urban and garrigue expansion on plateaux; extensive mixed agriculture on valley slopes and bottoms

was well underway by the mid- to late second millennium BC, for example in the Marsalforn valley on Gozo. This evidence equates with strong evidence for a period of maximum erosion from *c*. 1350–550 cal. BC, as observed in several deep valley cores such as Salina, Xemxija and Wied Żembaq in Malta. This landscape trajectory is supported up by the application of the revised universal soil loss equation to these same sediment cores, which also suggests that there was a major phase of destabilization and valley sedimentation occurring between *c*. 1550 and 1000 cal. BC. Although there is no absolute proof, this evident widespread disruption of the landscape might well signify the beginnings of extensive terraced field construction on the upper limestone slopes of the valleys.

From the sixteenth century AD the Blue Clay valley slope landscapes were intensively exploitated for arable agriculture, which led to later erosion and aggradation in the lower valleys, such as the Ramla valley of Gozo in the late nineteenth–early twentieth centuries. Nonetheless, the terrace systems established extensively across the islands in the British period by the late nineteenth century gave a substantial degree of stability to most of the valley slope landscapes, though they have not prevented continuing incision and down-cutting in the base of many valleys, a process which is still continuing today.

11.4. Discontinuities in Maltese prehistory and the influence of climate

Chris O. Hunt

There is a complicated relationship between climate and human activity which can be extremely difficult to grasp, because it is contingent on so many factors, because thresholds are so variable and because it is quite often very difficult to establish the magnitude of change, both in climate and in human response. Humans and their societies are extremely resilient and sometimes seem able to cope with significant climate and environmental change. At other times and in other places, what seem to be quite small environmental fluctuations seem to have led to (or at least coincided with) significant changes in human activity. Within the Holocene, our understanding of climate change is still evolving, but it is becoming clear that this was not a uniform period climatically.

Climate is the result of the aggregation of long sequences of weather events and many factors contribute to it. There is a tendency to reduce these to figures such as annual averages of rainfall or temperature, but there is much more texture to climate which can become hidden in these apparently simple figures, with things like the degree of seasonality, or the prevalence of extreme low or high temperature or rainfall events extremely significant in the lives of plants, and thus of the animals and humans dependent on them, if not to the animals and people themselves.

In the context of prehistoric Malta, our ability to resolve climatic variables is limited because we are dealing with the limiting factors of the techniques available to us. With the pollen evidence, it is difficult to discern temperature and rainfall changes because we are dealing with an extremely resilient, drought-tolerant flora, most of which is far from its climatic limits, and in particular because of the strong anthropogenic influence on vegetation since first colonization. Further, the concept of 'effective moisture' reflects the fact that plants respond not to rainfall totals *per se*, but to a complex interplay between rainfall, atmospheric temperature and humidity and the distribution of these variables through the year. The response of plants also varies depending on their growth habit. While herbaceous annual plants may respond fairly immediately to rainfall and effective moisture variation – in extreme cases not germinating at all or not flowering in major droughts – longer-lived perennials and especially trees may be able to 'ride out' several years of climatic stress because well-developed root systems may be able to access groundwater not available to shallow-rooted annuals.

Nevertheless, the main evidence for climatic change discussed in this volume is from the pollen analysis. It can be extremely difficult to separate stochastic variation in pollen statistics from the imprint of environmental events (Blaauw *et al.* 2010) and therefore replication of results from different sites is needed to separate signal from random noise. The interpretation of climatic data in the *FRAGSUS Project* has therefore relied on replication of signal between the project results and/or those of Carroll *et al.* (2012), Djamali *et al*. (2013), Hunt (2015) and Gambin *et al.* (2016). In locations where cereal cultivation and grazing were not greatly in evidence, we can interpret as a climatic signal the rise of tree and shrub pollen around 5000 cal. BC, and its persistence at high levels and eventual decline between 3000 and 2500 cal. BC. This is evidence for an increase and then decrease of effective moisture and we can rely on it because it is replicated in two or more cores. Minor fluctuations in percentages of tree and shrub pollen in our cores may similarly reflect minor variations in effective moisture, but correlation of these between our records is highly problematical because of the inherent uncertainties embedded in the dating models for individual sites.

Similarly, the Maltese terrestrial molluscan fauna is extremely well-adapted to the very variable climate of the Maltese Islands: most has been in place through many glacial/interglacial cycles and the animals can compensate for variations in climate by adjusting their distributions at the microscale in the landscape. Congruent points may be made about soils and sediments as climatic indicators – events lasting only a few months or years are unlikely to have left much impact on soils which evolved to prevailing conditions over many hundreds or thousands of years. The sediments record depositional facies, but again the Maltese Islands lie far from the climatic limits of most of the processes that dominated the Maltese Holocene.

One exception amongst the sedimentary evidence is the rare occurrence of gypsum in our cores (see Chapter 5). Although other geochemical routes such as the oxidation of pyrite in a calcareous environment can also lead to gypsum formation, most gypsum forms in recently deposited sediments in near-coastal situations as a response to extremely strong evaporation of sea-water in strongly seasonal environments (Poch *et al.* 2010). This happens today in *sabkhas* (coastal wetlands) on the shores of the Persian Gulf and in places along the North African littoral (Gunatilaka 2012). As such it is a signal for evaporative regimes stronger than present and thus extreme seasonality. Moreover, it can only have happened with sea-water incursion into the margins of the fresh groundwater lens of the Maltese lower aquifer, which could only be possible because of insufficient recharge by rainfall, before the era of groundwater abstraction by pumping. Layers in the cores containing gypsum are thus a signal for periods of low rainfall and extreme summer drought. These are indicated in Table 11.4, along with known contemporary events.

It can be seen in Table 11.4 that there is approximate coincidence between gypsum formation in our cores and major aridification events in the earlier Holocene. The later tree pollen minima in the Salina Deep Core may reflect other episodes of general aridity, although human activity in the landscape makes this less certain. There is also a coincidence between the formation of gypsum and these tree-pollen minima and several key moments in Maltese prehistory. It could therefore be suggested that climatic perturbations and particularly episodes of high seasonality present conditions placing societies under stress. These may be times where old ways of doing things and perceiving the world seemed unsuccessful, allowing new thinking and behaviours to become more easily established than at other times.

11.5. Environmental metastability and the *longue durée*
Chris O. Hunt

The *longue durée* in the Maltese Islands presents a picture of subtle, almost imperceptible change, which only really becomes apparent when comparing environmental and vegetation patterns over the millennia (Braudel 1966; Lee 2012, 2; Mathias 2015, 5) (Table 11.1). The vegetation of the rural environment of 30 years ago or of the landscape before settlement would be recognisable to a prehistoric Maltese farmer, although he or she might notice that the proportions of different plant species will have changed a little over this immense period of time. This change is because of the inherent resilience of the Maltese flora and the ability of many species to recover following impacts of natural hazards or human intervention, either because of their ability to disperse rapidly through seed or vegetatively, or for seed to remain viable in the soil over long periods until conditions again became suitable for growth. This resilience means that the basic configuration of vegetation has survived many *evènements* during the last 9000 years, including notable natural events such

Table 11.4. *Occurrence of gypsum in* FRAGSUS *cores and contemporary events (tree pollen mimima are those in the Salina Deep Core, which is most probably the least taphonomically impacted of our cores).*

Approximate date cal. BC	Depth (m)		Event
	Xemxija 1	Wied Żembaq 1	
6600	9.45–9.47 m		Tree pollen minimum and strong aridification across the western Mediterranean
6150	8.68–8.70		Tree pollen minimum and regional 8.2 ka BP aridity event
5900	8.33–8.35		Tree pollen minimum
5850	8.23–8.26		Tree pollen minimum
5450	7.85–7.87		Tree pollen minimum. Start of Għar Dalam phase
4800	7.25–7.27		Tree pollen minimum. Start of Maltese archaeological hiatus
4750		4.60–4.61	
4550		4.33–4.35	tree pollen minimum
3900	6.45–6.47		Tree pollen minimum. Start of Żebbuġ phase

as storms, tsunamis, floods, severe and long-lived droughts, and anthropogenic activities including vegetation clearance for agriculture and construction and the impacts of grazing animals. Similarly resilient, metastable vegetation is prevalent in semi-arid landscapes throughout the wider Mediterranean basin, from Jordan and Turkey in the east to Iberia and Morocco in the west (Bini *et al*. 2018; Magny *et al*. 2011; Peyron *et al.* 2017; Zanchetta *et al*. 2011; Zielhofer *et al*. 2010, 2017a & b), and the trends apparent in Table 11.1 are broadly duplicated during the Holocene across this immense area.

The Maltese (and wider Mediterranean) vegetation has its dynamic stability because of its history. For much of the Tertiary, the lands around the Mediterranean and much of North Africa supported humid forests (of which the last remnants are the Infra- and Thermo-Mediterranean woodlands, best represented in southwest Morocco). The climatic shocks of the Messinian Salinity Crisis, some six million years ago, when the Mediterranean became isolated from the Atlantic and repeatedly dried up, catalysed the development of dryland floras (Dansgaard *et al*. 1993; Pedley 1974; Puglisi 2014). The adaptability and resilience of these dryland floras was developed during the long sequence of late Pliocene and Pleistocene glacial episodes, which were marked in the Mediterranean by very rapid and unstable climate change and very considerable aridity.

One of the reasons for the stability of the human systems of the Maltese Islands over the *longue durée* has to be that the underpinning environmental systems were and are resilient. The aquifers were always present, so water was assured except possibly in the longest and hardest of droughts. It is symptomatic that freshwater molluscs were present at Xemxija through the period of declining rainfall which coincided with the last phases of the Temple Culture. Equally, the Maltese vegetation had resilient, dynamic stability and could recover from over-grazing, over-cultivation and the effects of natural hazards. Vegetation in other biomes, such as tropical rainforest or temperate deciduous forest does not have that resilience to the same degree. Degradation of less resilient vegetation would have had catastrophic consequences for people dependent on it. The changing climate did, however, have significant impacts on Maltese prehistory. The first farmers seem to have arrived shortly after the nadir of the 8.2 ka BP event. In contrast, this event in the eastern Mediterranean seems to have destabilized farming societies, sending a wave of emigrants into the western Mediterranean, including some who apparently reached Malta (Ammerman & Cavalli-Sforza 1984; Bini *et al*. 2018; Malone 2015; Whittle 1996). Life was probably a struggle for these first immigrants, whose population remained below the level of archaeological visibility for several hundred years. The only traces that we have found that reflect this early human presence are the pollen of their cereals and spores of the fungi associated with the dung of their domesticated animals.

The rise in population which culminated in the Maltese population becoming archaeologically visible during the Għar Dalam cultural phase (5400–4800 cal. BC) seems to have coincided with the start of a period of sharply rising rainfall. This may have allowed the expansion of settlement and cultivation of what were previously rather drought-prone and thus difficult soils. This climatically humid phase seems to have persisted through much of the Maltese Neolithic, including all but the latest phase of the Temple Period. It is noteworthy that there is evidence for land clearance by fire and substantial cereal cultivation during a second phase where the population seems to have effectively been archaeologically invisible, between *c*. 4800 and 3800 BC.

The Temple Period of Malta (3900–2350 cal. BC) seems to have been a time of relatively high rainfall. This seems to have allowed rainfed agriculture to flourish and cereal pollen percentages are generally high except at Burmarrad, where greater tree pollen percentages might point to an area of woodland maintained to provide timber for uses such as boat-building, construction and fuel. Prehistoric people largely depended on wood or dung for fuel, and dung would have been important for maintaining soil fertility when populations were dense and agriculture intensive. The persistence of this area of woodland further points to strong and effective social control mechanisms through a period of over 1000 years. The cereal and arboreal pollen at the other sites seems to have fluctuated during the Temple Period, perhaps consistent with some sort of long-fallow rotation.

Only in the Tarxien phase of the later part of the Temple Period (2850–2350 cal. BC) did the climate start to become more arid. The trend was not constant: there may have been an initial period of aridity, a second more humid phase and then further increased aridity. The association between locations with water and the temple sites no doubt started long before the Tarxien phase, but in a drying landscape decreasing rainfall would have made those temples such as Ġgantija that were associated with, and perhaps even controlled, persistent springs of particular significance (Ruffell *et al*. 2018).

At the end of the Tarxien phase (*c*. 2400 cal. BC) cereal cultivation seems to have ceased at most coastal locations. Only at Burmarrad did cereal pollen rise in the Tarxien Cemetery phase (2000–1500 cal. BC), perhaps because this was an inland location less vulnerable to raiding, or perhaps because drainage into this large alluvial basin would have enabled agriculture to be maintained when it was too arid elsewhere. Tree pollen increases slightly at several sites, but whether this reflects the cessation of human activity and a decrease in grazing pressure, or whether it is a response to rising rainfall, is presently unclear.

From that point to the present day, Malta's climate seems to have been largely semi-arid, with intermittent droughts. There seem to have been shifts in the emphasis of farming, with cereals of importance in the Later Bronze Age and Punic periods, and olive cultivation beginning in the late Punic period but with increased significance in the Roman period. By Classical times, soils were extremely degraded, with the sediments of this period in the Victoria Caves being derived from unweathered bedrock. The Roman period also saw the establishment of a pine plantation at Xemxija, perhaps providing suitable timber for ship building. The plantation at Xemxija seems to have been cut down about 1000 years ago. There is little detailed evidence in our cores for later periods, but what there is points to the continuation of cultivation and grazing in a highly degraded landscape.

The continuity of the *longue durée* contrasts with rapid, catastrophic change in the modern landscape, which is currently being over-run by introduced eucalypts, wattles and the Cape violet (which have no local natural competitors and thus flourish unchecked) and by construction. It is ironic that the Maltese vegetation, which for 9000 years has survived almost unchanged despite everything that the environment, people and their animals could do to it, has perhaps changed more during the lifetime of the *FRAGSUS Project* which was set up to study the resilience of this island environment.

11.6. Implications for the human story of the Maltese Islands

Charles French, Chris O. Hunt, Caroline Malone, Katrin Fenech, Michelle Farrell, Rowan McLaughlin, Reuben Grima, Patrick J. Schembri & Simon Stoddart

Environmental studies for understanding archaeological cultures in the Maltese landscape commenced with the 1987–95 Cambridge Gozo Project, which attempted to identify preserved deposits that might illuminate a much-neglected area of archaeological study in Malta. The main achievements of that work were the analyses of molluscan remains that described the local prehistoric environment (e.g. Hunt & Schembri 1999; Schembri *et al*. 2009), since the focus on a subterranean burial complex was always unlikely to produce significant organic economic evidence, other than animal bones and molluscs. The landscape survey of the Xagħra environs attempted to classify the surface archaeology in relation to the underlying soil and geology, using the standard maps available. The collected data provided adequate information for a GIS study of human settlement set against the natural landscape (Boyle 2013), showing that settlement choice was closely linked to a range of factors including access to springs, good soils, wind direction, slope direction and gradient. However, without additional new research the interpretation of human activity and the history of the landscape itself was impossible. Thus, one goal of the multi-disciplinary approach of the *FRAGSUS Project* was to establish a much more detailed and accurate understanding of landscape evolution and its role in the development, sustainability and demise of prehistoric cultures on the Maltese Islands.

The *FRAGSUS Project* immediately recognized that once the physical surface of present-day Malta and Gozo was examined, there was an extensive captured palaeoenvironmental and archaeological story preserved in many places, notably where protected by surviving prehistoric monuments (Fig. 11.4). Initially this survival was a surprise, especially given the evident and transformative soil erosion, coupled with extensive agricultural terrace construction and encroaching modern development. The execution of new on- and off-site fieldwork rapidly demonstrated the potential horizons for new data collection and analysis. The huge potential of sedimentary cores for understanding the focus of human activity over time through using erosion as a proxy is significant. Moreover, the substantial depths of burial in the valley systems of Malta suggest that we are probably recovering a very skewed archaeological record.

Despite this new research, there is still little demonstrable archaeological evidence of people in the landscape prior to about 6000 cal. BC, but there are plenty of hints that people were already present and altering the varied Maltese landscapes from that time. Across the wider central Mediterranean area, there is little clear stratigraphic evidence for actual agricultural settlement before *c*. 6000 cal. BC west of southeastern Italy (Natali & Forgi 2018). That evidence is profoundly affected by the absence of stratigraphic control except in the western Sicilian caves of Uzzo and Oriente. In these two caves, there is Impressed Ware from 6200 cal. BC, but it is not clear how much this material was connected to any level of intensive agricultural practice (Lo Vetro & Martini 2016; Tinè & Tusa 2012). Malta, although only separated by *c*. 80 km from Sicily, was far less connected, and required adequate maritime technology to enable a reliable passage to and from the islands from nearby landmasses. It is quite possible that early prospectors visited Malta, as they had done on Cyprus

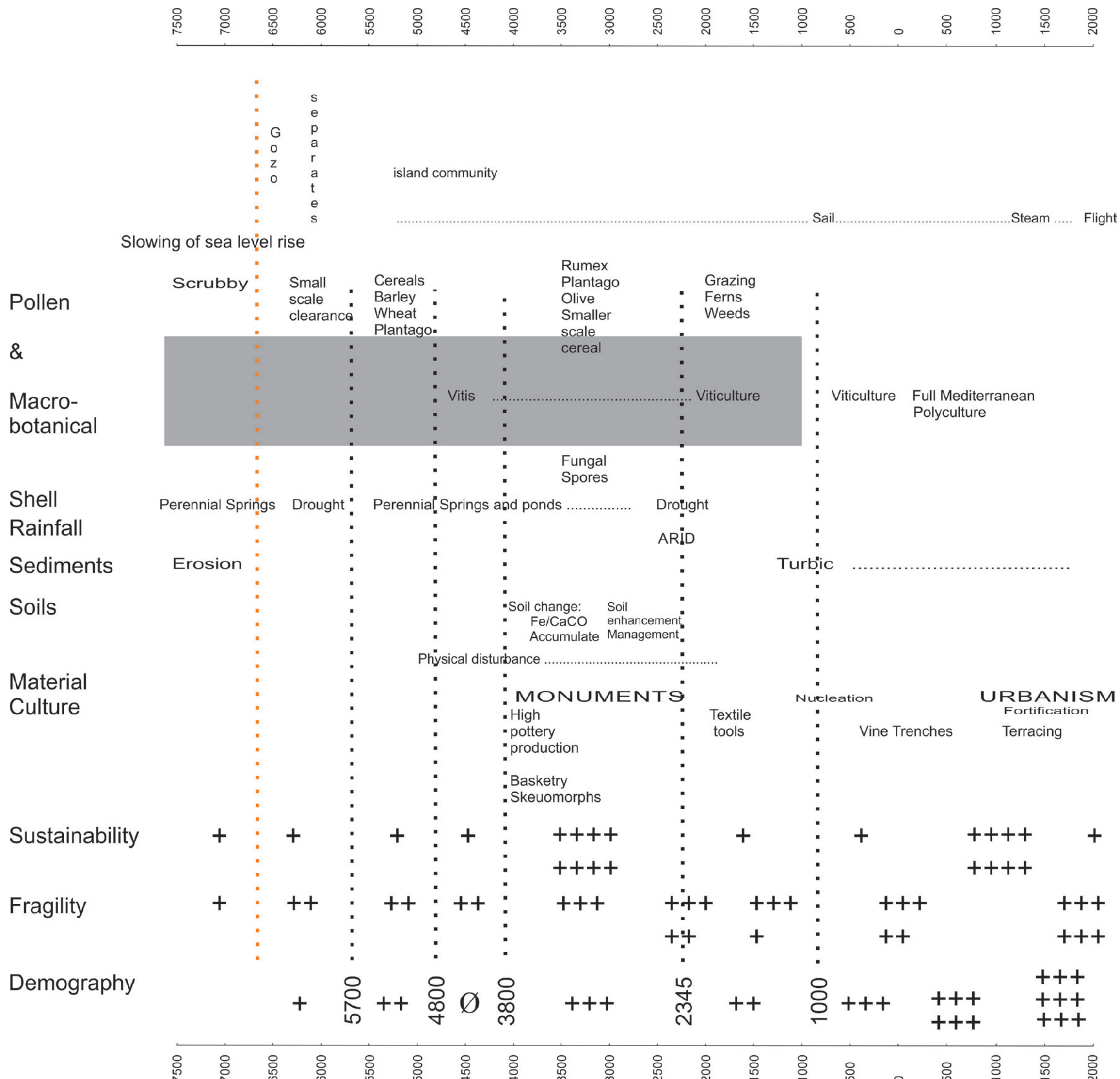

Figure 11.4. *The main elements of a new cultural-environmental story of the Maltese Islands throughout the last 10,000 years (R. McLaughlin and S. Stoddart).*

a millennium earlier (Guilaine *et al*. 2011) to exploit certain resources. That there is still no clear evidence for pre-Neolithic settlement or dated deposits with human activity connected on Malta may be explained by the likely transient nature of such visits, and the superficial remains that resulted. Perhaps periodic visitors lit fires as suggested by charcoal in the lowest parts of the Marsa 1 and Salina Deep cores. At Marsa, two recycled dates of *c*. 23,000–25,000 cal. BP (Carroll *et al.* 2012) might point to such an event, although natural fires are equally probable. Such expeditions clearly did not last long or become permanent. What is relatively clear is that longer term occupation of Malta, after it became an island, required an agricultural input, since the biomass in such a restricted area was unlikely to have been sufficient to sustain a preagricultural population on a long-term basis (Malone 1997–8). In this major respect, occupation of Sicily was very different given its much larger land mass and the recorded evidence from the western caves for a transition from Hunter Gatherer to Agricultural economy. As for the nature of the agents of this transformation of economic life, the preliminary genetic evidence (Ariano *et al*. in press) suggests a closer relationship with modern Sardinian and LBK Neolithic groups than other Mediterranean Neolithic groups, and less affinity with western hunter gatherers, since they could have had very little economic stability on such a small island archipelago.

At about 6000 cal. BC, Malta had a general background vegetation of *Pistacia* scrub woodland expanding into a steppic landscape on the limestone plateaux, driven by increasing effective humidity within an otherwise relatively dry period. The local environment presented useful resources for early settlers. For example, well-developed brown Mediterranean soils were associated with the scrub woodland landscape, especially on the Upper Coralline Limestone bedrock areas, and rich silt loam soils on the Globigerina Limestone areas. At low altitude, there were freshwater streams and shallow, wet marshy areas in many of the valley bottoms close to the seashore, such as at Salina, Xemxija and Wied Żembaq. This earlier Holocene landscape picture soon began to change. At Salina for example, there were at least two early episodes (6858–6419 and 6350–6037 cal. BC) showing an increase in herbs and grasses as well as a sporadic presence of nettles, ribwort plantain and ruderals and some regression of scrub woodland accompanied by mycorrhizae. This change clearly hints at the presence of some bare and disturbed ground, perhaps associated with grazing fauna, and the beginnings of soil erosion, which is particularly marked in the base of the Xemxija core at the same time. That erosion was also coincident with a more general decline in rainfall in Malta, most probably associated with the wider 8.2 ka BP event leading to an aridification trend in Mediterranean coastal areas.

In the early sixth millennium BC, the first clear signs of agriculture can be observed. These involved arable cultivation with the introduction of wheat and barley, together with a ruderal flora, and ribwort plantain and nettles that indicate grazing. There was still some scrubby woodland, but the landscape became more grass-dominated with some areas of maquis and garrigue, which together suggest a relatively dry seasonal Mediterranean climate. Thus, the collected evidence indicates that there were already agriculturalists in this landscape prior to the 'Earlier Middle' Neolithic (Għar Dalam and Skorba phases), making the first inroads as farmers into a less than fully resilient landscape.

From the middle of the sixth millennium BC, the first solid evidence for human settlement is recorded at Santa Verna, in the buried deposits and land surface beneath the later fourth millennium BC temple levels. Għar Dalam-Stentinello pottery is present amongst the artefacts of that first settlement phase, a type familiar across eastern Sicily and Calabria and off-shore islands in the second phase of Neolithic populations. It is very interesting that Malta appears currently to lack (see Chapter 2 & Volume 2) the first *impressed* phase of pottery which is present in Southern Italy and Sicily (Natali & Forgi 2018) dating to *c.* 6200 BC. The chronology of the current pottery repertoire from Malta compares well with the best dated sites of Capo Alfière in Calabria (Morter 1990) and Curinga (Ammerman 1985), and reflects a trend of settlement and farming over the entire region (Malone 2015). The charred remains of the wheat, barley and pulses grown on Malta and the bones of domesticated sheep, goat, pig and cattle are found in close association with the pottery during this phase of its settlement.

As the sixth millennium progressed into the fifth millennium BC, the trends of expanding settlement and agriculture continued, and especially the expansion of plants indicative of pastoral activities. Cereal cultivation did continue however, probably in fits and starts and at different frequencies, with spatial variations. The corroborative evidence of macro-botanical data of wheat/barley and lentils from the buried soils beneath the Santa Verna and Skorba temples date to about 5400–4900 cal. BC. The varied mosaic of arable and pastoral agriculture could be related to the topography and geology of the islands (see Chapter 6) as much as human endeavour, with the more water retentive Blue Clay geology and Greensand/Upper Coralline Limestone geological contact zone associated with springs and more structured soils, as opposed to the free-draining Globigerina Limestone areas. It is also possible that the Blue Clay valley areas could have been utilized differently compared with the adjacent higher limestone areas, and were instead used for livestock pannage with easy access to springs, as well as natural raw materials such as reeds and withies for house building purposes.

Importantly, there may have been some management of the Upper Coralline Limestone slopes and soils from about 4650 cal. BC. The evidence is slight, but has merit. First, there is a slight increase in *Theligonum* pollen, characteristic of dry rocky environments such as those provided by terrace walls, alongside palynological evidence suggestive of increased agricultural activity. This evidence is seen in the Burmarrad sequence, where it was suggested that similar management may reflect the advent of terrace construction in the landscape (Djamali *et al.* 2013). Although other evidence for this was not identified then by the Bumarrad project, there is now good evidence of soil amendment of topsoils with settlement-derived refuse beneath the Santa Verna and Skorba temples at some point prior to *c.* 3800 cal. BC. Similar amendment was also identified later in the earlier to mid-third millennium BC at Ġgantija. These examples certainly point to early attempts at soil management of arable land on the upper margins of the Upper Coralline Limestone plateaux. There is also evidence, in the form of algae and dinoflagellate cysts, for irrigation at Santa Verna and Ġganitija in association with these very early soil amendments.

From about 4550 cal. BC onwards, there appears to have been a general decline in agricultural activities, with an apparent reduction in intensive cereal cultivation coupled with a relative expansion in scrub/tree pollen (Figs. 11.1–11.3). This change could be coincident with a period of higher effective rainfall, and there appears to be palynological, molluscan and soil evidence from this project for a period of relatively higher moisture considerably earlier than the beginning of temple construction, specifically between about 4750–4250 cal. BC. This evidence, however, is in contrast to the generally decreasing rainfall trend seen elsewhere around the Mediterranean at this time (e.g. Magny *et al*. 2011; Sadori *et al*. 2008, 2016; Jaouadi *et al*. 2016; Bini *et al*. 2018). At the Skorba and Santa Verna temple sites during this period, there is an apparent hiatus in the archaeological occupation evidence of settlement beneath the later temples, which reveals a very clear gap in the comprehensive radiocarbon dating records now available (see Chapter 2 & Volume 2, Chapter 2).

Nonetheless, the palynological records clearly imply that cereal cultivation continued throughout the mid- to later fifth millennium BC, coupled with on-going soil erosion and aggradation in many of the valley sequences. Although it is tempting to suggest a major depopulation of the islands, we could also consider the changes as indicative of a reorganization of less intensive activities and landscape exploitation. There is what seems to be evidence for human activity in the landscape from the pollen analyses, which show the continuation of cereal pollen and indicators of grazing throughout the fifth millennium BC. While livestock, if abandoned by their keepers, might be expected to continue living in the Maltese Islands, domesticated cereals are dependent on people for their propagation and would be unlikely to continue as a significant component of the vegetation without human intervention. However, evidence of early agricultural settlement elsewhere (i.e. Cyprus especially, but generally across early Neolithic Europe) does indicate that early settlers frequently abandoned their attempts to establish occupation of a new area (see also Shennan 2018). There are a multitude of reasons for this, but a small restricted and relatively isolated island would have presented challenges to communities more familiar with extensive subsistence practices in a larger, connected landmass where migration or seasonal movement was feasible.

From the Middle–Later Neolithic period at about 4000 cal. BC, the Maltese island landscapes became primarily open land used for grazing, probably coupled with intensifying cereal cultivation. This is a period of apparent intensive reoccupation, or at least a growing population and denser settlement. It is also a period during which a strongly Sicilian-related culture became established on Malta (Żebbuġ) and saw the development of aggregations of domestic and more elaborate proto-temple structures. Many, if not all, of the sites that later became major megalithic buildings (temples) had their origins in this period (Bonanno *et al*. 1990) which was also characterized by subterranean rock cut tombs, clustered for the most part in small cemeteries. Evidently locales, territories and identities were important components of settlement and burial for the Żebbuġ communities. It was a period of intensive production, as seen by the enormous quantities of pottery made and fired during the Żebbuġ phase (*c*. 3800–3600 cal. BC), indicative of storage and consumption at a new level when compared to previous periods (see Volume 2, Chapter 10). The firing of the pottery in particular might suggest a significant impact on timber resources, but there is little sign of this seen in the pollen record (Fig. 11.1).

In association with expansion and intensification, soil change was occurring as evidenced by the increasing secondary formation of both silt-sized calcium carbonate and amorphous iron oxides in the later Neolithic palaeosol profiles. As mentioned above, there are also indications of soil amendment at Santa Verna, Ġgantija and Skorba. Nonetheless, in places these changes occurred at slightly different times, represented by short-lived peaks in the pollen record of lentisk scrub regeneration at Salina and Burmarrad, which perhaps indicate shifting patterns of exploitation in the landscape and even some kind of soil and/or land management, possibly even long-fallow crop rotation in different fields. The creation of several megalithic monuments on the Globigerina Limestone lowlands of southeast Malta may also be an indication of demographic shifts related to changing patterns of exploitation. In tandem, the frequencies and biodiversity of agricultural weeds in the pollen assemblages increased, suggesting a proliferation of these taxa. This ruderal flora could indicate dry and patchy open ground, but would have been ideal for pastoral activities, shifting over relatively short distances. Conversely, there may also have been reduced productivity from land left to long periods of fallow, which is at odds with the indications of settlement expansion and the likely demands on increased production. The presence of spores of soil fungi however, suggest continuing soil erosion, with many of the valleys such as Xemxija infilled with eroded soil material, and perhaps this signals an economic system that was already showing signs of stress and instabilty. Furthermore, the fluctuating richness of pottery finds and the sporadic nature of occupation at sites like Taċ-Ċawla and Santa Verna suggest that human activity may have oscillated to some degree throughout the later fourth to third millennia BC (see Volume 2, Chapters 3, 4 & 10).

Towards the end of the Neolithic, from around 2700 cal. BC, there may have been a major shift in emphasis in landscape use, associated with socio-cultural changes which are not fully understood. Many of the smaller temple sites were abandoned (including Santa Verna and Kordin III), whilst others (such as Ġgantija) grew in significance and perhaps in economic influence (see Volume 2, Chapters 4–6). The many interpretations of the role and function of megalithic temples within the later Neolithic society of Malta are varied and lively, but it is highly likely that they played an important economic and social role. The interior spaces of the megalithic structures contained storage and cooking facilities, feasting debris and masses of pottery, grindstones and installations intended to display most likely, food and feast. Therefore, one interpretation is that the structures were used in competitive feasting (Malone 2017; Malone *et al*. 2016; Barratt *et al.* 2020).

There are very high (>10 per cent) cereal pollen frequencies at or very near to several temple sites during the Temple Period (Żebbuġ-Saflieni-Tarxien phases) of *c*. 3800–2400/2200 cal. BC which is compelling evidence for food processing at these sites. The increased cereal pollen may also coincide with two periods of relatively higher effective moisture at about 3450–3050 and 2850–2650 cal. BC. There were also vines evident in the Żebbuġ phase and carob occurred in the Tarxien phase, both plants representing new resources which could suggest a broadening of the subsistence base, as well as an increase in processing activities in close proximity to some of the temple sites in their latest phase of use.

In the last centuries of the third millennium BC, several changes occurred simultaneously at the end of the Temple period. Cereals declined, scrub woodland contracted, the steppe areas appear to have been drier, and the once marshy, lower valley zones were drying out. These changes are complemented by both the archaeological and osteological data from Gozo which suggest changing and more difficult times around 2550–2450 cal. BC (see Volumes 2 & 3). At the same time, there are indications of drought in the molluscan records from the deep cores in Malta (see Chapter 4). In addition, wider regional records from the Mediterranean area indicate that a significant change in hydrological conditions was taking place, with more arid climatic conditions and locally cooler temperatures taking hold between about 2350 and 1850 cal. BC, that were locally and seasonally varied (Bini *et al.* 2018; Di Rita & Magri 2019). Concurrently, in the valley/coastal zones at Salina, Xemxija and Wied Żembaq, there is evidence to demonstrate a decline in both cultivation and pastoral activities, suggesting a shift away from exploitation of the coastal margin zones to a renewed focus on more inland areas. Although it is not possible to identify many new archaeological data during this period, given the paucity of records for the final phases of the Temple Culture and its successor in most investigated sites, the palynological and soil erosion records corroborate the final centuries of the third millennium as a period of distinct land-use change.

During the Early Bronze Age, current evidence suggests that settlement partly continued in the same locations such as Ġgantija and the Xagħra Brochtorff Circle, partly returned to old locations such as Santa Verna, and partly started the trend toward defendable locations such as Ta’ Kuljat (see Chapter 7). This settlement shift all occurred after the well-recorded 4.2 ka BP climate event, and there is extensive evidence for widespread cultivation and agricultural activities during the Bronze Age occurring during a time of climatic stability. By contrast, the soil evidence indicates accelerated accumulation in many of the valley bottoms from at least the mid-second millennium BC, such as at Marsalforn, Salina, Xemxija and Skorba. This erosion could indicate that new areas of the landscape in the hinterland valleys were being exploited for the first time, and/or were being more intensively utilized. Interestingly, the freshwater input to valley bottoms such as at Xemxija was now drastically reduced, which could reflect greater uptake of groundwater higher up the catchment associated with increased agricultural activities. Moreover, whilst these features could well be related to the establishment of terraced field systems, they may well be more coincident with the Upper Coralline Limestone areas than anywhere else. Unfortunately, well dated evidence for the extensive development of terracing in later prehistory is not yet available from these islands.

By the Final Bronze Age, settlement tended to be concentrated either on prominent defendable inland hill-tops (In-Nuffara for example) or on defensive coastal promontories (such as Borġ in-Nadur and Baħrija). Such locations frequently had no direct access to agricultural land. The main period of destabilization in the landscape evident in the sediment sequences investigated in this project dates to between *c*. 1550 and 1000 cal. BC. Culturally, this ‘Borġ in-Nadur’ time frame saw significant changes in settlement patterns on Malta, compared with the previous more stable periods. These changes included the construction of defended settlements in prominent locations (Tanasi & Vella 2015) (see Chapter 7) and probably also the contemporary ‘cart-ruts’ that led from hill-tops to valley bottoms (Evans 1971, 203; Magro Conti & Saliba 2007). These latter features may have served to draw soil up-hill for agricultural purposes, so that food could be grown near the defended settlements, rather than in valley bottoms as is the case today. This drastic intervention differed from management practices in the Neolithic and Temple periods and may well have led to the loss of more soil than before. Certainly, the stratigraphic and OSL evidence from the Marsalforn valley in Gozo, for example, indicates severe erosion and substantial accumulations of eroded soil material in valley bottoms from this same period. More geo-archaeological testing of the cultivated valley-scapes of today is required to judge how widespread a phenomenon soil erosion was during the latter half of the second millennium BC across the Maltese Islands, but every indication is that this was extensive.

Evidence for earlier prehistoric terracing is much harder to pin down. Certainly, the earlier Holocene palaeosols under the Santa Verna, Ġgantija and Skorba temple sites all exhibit indications of having received both settlement waste and also some soil build-up. This is most probably indicative of some soil management and conservation practices, but it does not necessarily imply that terraces were being constructed in the later Neolithic over the whole landscape. Djamali *et al*. (2013) have suggested that *Theligonum* (dog cabbage) pollen may be used to infer the establishment of terraces, based on the observation that in Mediterranean France and Corsica terrace walls are intensively colonized by this taxon. In Malta, there are indeed increases in *Theligonum* pollen (to *c*. 5 per cent) at Burmarrad between *c*. 4650 and 2550 cal. BC. There is also a slight increase in *Theligonum* pollen which accompanies other evidence for increased agricultural activity, and it is consistently present from *c*. 5000 cal. BC throughout the Salina Deep Core pollen sequence. However, one indicator of dry rocky ground is probably an unreliable single identifying feature for the advent of terracing. It is much more likely that terracing began in response to the need from the latter part of the second millennium BC to slow soil erosion and conserve soil and limited moisture, but clearly this question requires much more extensive proof from detailed landscape analyses with good chronological control (see Chapter 7).

In addition to this circumstantial *Theligonum* 'indicator species' evidence, there are a number of other palynological, stratigraphic and palaeosol hints that point to human management and exploitation of the landscape, which of course could include terrace construction. Shrubs/scrub and trees decline from about 4000 cal. BC, but especially towards the end of the Temple period from *c*. 2350 cal. BC. This appears to be coincident with pollen evidence for the intensification of agricultural activities, both arable and pastoral. At the same time, the palaeosol record is exhibiting strong hints of increasing aridification, making the soils around several of the Neolithic temples much more calcitic and affected by oxidation and rubification. At this time and slightly later within the late third and into the early to mid-second millennia BC, there are strong hints of human attempts to enhance soil A horizons through the addition of settlement-derived midden material, for example soil aggradation at Ġgantija that may indicate a managed arable field. There is also evidence for substantial hillwash erosion and accumulation in many valleys such as Marsalforn on Gozo and Xemxija on Malta. All of these datasets suggest widespread greater attempts to manage, manipulate and adapt the agricultural landscapes of the Maltese Islands physically, and these may be our best currently available indicators that terracing of some valley slopes had begun.

Soil erosion management and terracing trends appear to continue and intensify over time most probably aggravated by autumn rain storms and minimal vegetative cover during the later Bronze Age, Punic and Roman periods (Mitchell & Dewdney 1961; Mayes 2001). Settlement expanded and it seems to have become more widespread, especially on the plateau areas (see Chapter 7). Cereal cultivation increased in the Punic period, and, by the time of the Roman occupation, intensive landscape management and terrace construction was routinely practised to control serious soil erosion. The same erosion was coincident with domesticated olive and vine cultivation, probably on a widespread and intensive scale (Bouby *et al*. 2013; Caracuta 2020; Carroll *et al*. 2012). Although some trees and shrubs persisted, the landscape mainly supported a ruderal dominated grazing land, which was degraded and continued to be subject to soil erosion during the winter rains. Freshwater stream and pond habitats generally continued to decrease.

From the Roman period onwards, the vegetation and landscape features described persisted, but pine trees increased in some areas and that increase continued into the Medieval period, alongside grassland and pasture. The more intense soil erosion of the Roman period was undoubtedly enhanced by the effects of the introduction and use of the mould-board plough (Margaritis & Jones 2008). That technology turned the soil clods over and thereby increased their exposure to both drying out and rain-splash generated erosion, in turn generating further soil erosion downslope (Jongerius 1983; Kirkby 1969; Lewis 2012). Soil erosion was also exacerbated by the widespread and risky strategy of olive and vine cultivation; risky since traditional management typically left the soil bare and loose. This would have led to increased vulnerability to soil erosion, unless the crops were grown together with an understory of vegetation or multi-cropping was practised (Loughran *et al*. 2000; Kosmas *et al.* 1997;

French 2010). The outcome was the development of open karstland, with poor, patchy vegetation and frequent zones of bare soil predominant across the landscape.

From the fourteenth century AD onwards, there was increasing nucleation of settlements, with a general tendency to occupy inland and upland areas (see Chapters 7 & 10). A combination of subsistence arable farming and livestock grazing was the norm with scattered farmsteads in the wider countryside (Chapter 9). By the late Medieval period, many villages were deserted, and the focus shifted to the few urban centres in defendable positions such as Mdina, Birgu and Gozo Castello. Only in the Knights of St John period from the later sixteenth century did the Grand Harbour area (later Valletta) become the main commercial hub of Malta. The early modern period saw new areas of the landscape being exploited and developed with terracing, such as the Blue Clay geology slopes in the Ramla valley of Gozo. The Knights Period also saw terracing systems installed over almost all parts of the islands. This regime of management was effectively continued in the British Period during the nineteenth century, with cotton introduced alongside cereals forming a very important crop in its own right. Indeed, as seen in the cadastral maps (*cabrei*) which also recorded land-use, a highly developed terraced and enclosed landscape arose as a result of this progressive intensification, which culminated around the end of the nineteenth century. Its traces are still visible today in most valley landscapes on the Maltese Islands.

Another enduring characteristic of the exploitation of the Maltese landscape is the mixed strategies that were developed in response to the very varied constraints and opportunities offered by different parts of the islands, often in close proximity. Like many Mediterranean environments (Horden & Purcell 2000), the Maltese archipelago presents a number of highly fragmented landscapes (see Chapter 6). Agricultural practices and subsistence strategies were and are heavily conditioned by these variable characteristics. Land unsuitable for crop cultivation may provide ideal environments for sheep and goat grazing. Many parts of the coastal areas were probably always too precipitous and inclement to host good arable land, especially on Malta's windy and dry northwestern coastline, likewise the Blue Clay valley slopes, especially in northern Malta and Gozo. Cultivable land irrigated by a source of freshwater allows different crops to be grown compared with land that receives no water other than rainfall, making some zones of the landscape, such as the Greensand/Upper Coralline geological boundary zone on the north side of the Ramla valley and Xagħra plateau, more sought after than others. The response to these constraints was often the long-term development of mixed strategies which were ultimately more resilient against climate and crop failure (McLaughlin *et al*. 2018).

Although Malta is an island landscape, many of its characteristics are shared with those countries of the Mediterranean fringe of southern Europe. It would have been similarly affected by a fast-rising sea level and loss of coastal margin land during the early Holocene, as well as the disappearance of wild animal species, even if it acted as an isolated refugium for a while. The *FRAGSUS Project* has definitively revealed that people were in this landscape as early as *c.* 6000 cal. BC, who were farming and, at least in part, beginning to de-stabilize the landscape. Yet in spite of over a millennium and a half of this palaeoenvironmental evidence of activity, there are few if any known sites until the construction of the first temples from about 3900 cal. BC. Does this mean three cycles of Neolithic colonization? The first cycle before 6000 cal. BC appears to have occupied a part of the landscape that is no longer preserved or too fragile to have been so far detected. The second cycle has been detected at least under later monuments, and its practitioners may have moved around the landscape to maintain their resilience. The third cycle adopted new social strategies embedded in the 'temple' structures, focused on watered horticultural enclaves within the fragmented landscape, and was for fifteen hundred years highly successful. These issues are further discussed from a site based perspective in Volume 2. Within these generalized patterns, there were different regional trajectories in play, since the first temple sites in Gozo and northern Malta underwent modifications throughout the Neolithic through to the mid- to later third millennium BC. In contrast, the temples in south and east Malta appear to have developed slightly later and were apparently abandoned somewhat earlier. Whilst there is no break in later Neolithic Tarxien phase evidence, there was decreased farming activity in the later third millennium BC. Whether this decrease reflects population reduction, or people emigrating from the islands, or just a different, more dispersed form of subsistence farming is still to be established.

The degree of connectivity in the Later Neolithic is still difficult to measure with precision. Much of the material and organic world was locally sourced. Some parts of the material world (e.g. some chert, obsidian and greenstones) were procured in quite modest quantities from outside the islands. Some individuals (or their ancestors) also had histories from outside worlds, as indicated by the emerging genetic history of some individuals from Xagħra. These issues are more thoroughly explored, and increasingly quantified, (see Volumes 2 & 3). Some connectivity with lands beyond Malta were always sustained, if not always visible in the archaeological record, but the limited technologies of navigation would have provided a substantial brake on movement of materials and people, until it becomes much more widespread from Phoenician, Punic and Roman times onwards. Increasing trade and exchange may well have gone hand-in-hand with a greater resilience of the islands' economy and therefore created the potential for population growth (see Chapter 7). This combined economic development and population growth with a wide social hierarchy became much more evident from the mid-fifteenth century onwards with influences from different parts of Europe, namely the Arabs, the Normans and the Spanish.

Throughout these later periods, the importance of soil and preventing its erosion must have been a constant concern. Indeed the Medieval 'Red Soil Law' was incorporated into the Fertile Soils (Preservation) Act of 1973, where red soil discovered on building sites has to be gathered and saved. As land quality varies with respect to the geology and different zones of each valley landscape over very short distances, this would have favoured an interconnected arable and pastoral economy. Increasing new land ownership from the sixteenth century AD may then have enabled a shift from a more subsistence base to greater cash-cropping and land-use intensification with the development of courtyarded farmsteads and new towns. Despite evidence of some ebb and flow of people and activity in the Medieval period with de-population from time to time (eg. Gozo in AD 1551, Knights period from AD 1565–1798, British period) there was renewed occupation of the islands and the expansionary uptake of land for farming, especially on to the Blue Clay valleys of Gozo.

The work of the *FRAGSUS Project* reveals immense variation in the development and use of the Maltese landscape over very short periods of time. When set within the wider Mediterranean climatic and palaeoenvironmental sequences (cf. Bini *et al.* 2018), the data obtained on Malta and Gozo correspond with regional trends, but there is not necessarily a direct correlation of events in time. Clearly wider regional and sub-regional environmental changes, especially changing rainfall patterns, affected the livelihoods of the prehistoric people of Malta and Gozo. Each valley, however, tells its own slightly different story of agricultural exploitation, erosion and management, reflecting a wider regional picture of fragmented variation. During the lengthy Maltese Neolithic period (over 3000 years in duration), temple construction and land-use can be set against a changing and extensively exploited agricultural landscape. Over centuries, the landscape of the Temple Period suffered vegetational and soil change and erosion, with changing patterns of use and economic productivity governed by a number of factors. These patterns vary according to location, slope by slope, valley by valley, geological substrate by substrate, and potentially inform on the longevity and economic success of the many temple sites, some of which were abandoned earlier in the sequence. Such variation is observed in the Pwales valley at Xemxija in Malta, where there was evident and sustained soil erosion from the earliest Neolithic activity, but at Salina towards the coast the valley landscape remained wet and marshy throughout much of prehistory. On the Xagħra plateau on Gozo, there was sustained human exploitation associated with soil-type change and thinning for at least a millennium and a half through much of the Neolithic period. Although the soils on this plateau were degrading slowly, there appears to have been no severe erosion evident in the associated valleys until about a millennium later from the mid- to later second millennium BC. Thus, there was probably much more understanding by prehistoric people about how to utilize and cope with the inherently unstable landscapes of Malta and harness the resilience in the soil-vegetational system, despite the longer-term aridifying trend, than has been credited hitherto. As the saying goes, *Mingħajr art u ħamrija, m'hemmx sinjorija* (without land and soil, there is no wealth) (Joe Inguanez, pers. comm.).

Today, it is to be hoped that this underlying landscape resilience will continue despite the creeping advance of modern development, industrialized exploitation and settlement pressure. The goals of the *FRAGSUS Project* were designed especially to understand the economic and technological means that sustained an ancient culture in a very small island context. In large part, that goal has been met, and with it, a greater understanding of the much longer time frame within which the Maltese Islands evolved. Undoubtedly, many of the aspirations to expand knowledge and understanding have been achieved, especially insight into the close association of local environment, soil and climatic instability that supported complex social systems in the past, and potentially will continue to do so into the future. An important lesson of balance emerges from this study, one that demonstrates conclusively that when climate fluctuations occur, human over-exploitation of natural resources in fragile environments invariably results in episodes of quite dramatic retrenchment, and even complete collapse. This is repeating story of human civilization in marginal areas, such as Iraq and the

Maya lowlands (Mathews 2005; Webster & Evans 2005), but it is also one repeated in regions of much greater environmental wealth and resilience.

As the companion volumes in this project publication series demonstrate, the human story of survival in early Malta is one of resourcefulness coupled with destructive activities, advanced social structures and the ability to intensify activity in a manner only seen in small island systems in prehistory. The hope has been to see patterns in the past that inform us in the present, and perhaps influence human behaviours in the future, enabling conservation and protection of vulnerable environments, whatever the wider climatic world may act out.

Temple landscapes

The ERC-funded *FRAGSUS Project* (*Fragility and sustainability in small island environments: adaptation, cultural change and collapse in prehistory, 2013–18*), led by Caroline Malone (Queens University Belfast) has explored issues of environmental fragility and Neolithic social resilience and sustainability during the Holocene period in the Maltese Islands. This, the first volume of three, presents the palaeo-environmental story of early Maltese landscapes.

The project employed a programme of high-resolution chronological and stratigraphic investigations of the valley systems on Malta and Gozo. Buried deposits extracted through coring and geoarchaeological study yielded rich and chronologically controlled data that allow an important new understanding of environmental change in the islands. The study combined AMS radiocarbon and OSL chronologies with detailed palynological, molluscan and geoarchaeological analyses. These enable environmental reconstruction of prehistoric landscapes and the changing resources exploited by the islanders between the seventh and second millennia BC. The interdisciplinary studies combined with excavated economic and environmental materials from archaeological sites allows Temple landscapes to examine the dramatic and damaging impacts made by the first farming communities on the islands' soil and resources. The project reveals the remarkable resilience of the soil-vegetational system of the island landscapes, as well as the adaptations made by Neolithic communities to harness their productivity, in the face of climatic change and inexorable soil erosion. Neolithic people evidently understood how to maintain soil fertility and cope with the inherently unstable changing landscapes of Malta. In contrast, second millennium BC Bronze Age societies failed to adapt effectively to the long-term aridifying trend so clearly highlighted in the soil and vegetation record. This failure led to severe and irreversible erosion and very different and short-lived socio-economic systems across the Maltese islands.

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